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The Investigator

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JUNE 1960

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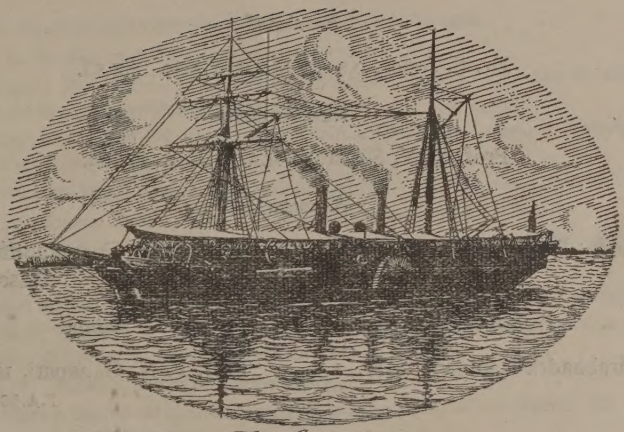

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DONATION

The Association places on record the generous donation of Rs. 500.00 received from the INDO-NORWEGIAN PROJECT, Neendakara, Quilon (Kerala).

SYMPOSIUM ON SCOMBROID FISHES

Scombroids constitute one of the most economically important groups of marine fishes and of these, the mackerel and to some extent the seer fishes form regular fisheries in many areas while the tunas and the billfishes are of potential value with considerable scope for development. Our knowledge about them in general in the Indian region is rather meagre and even the available information is scattered. It is therefore proposed to hold under the auspices of the Marine Biological Association of India a symposium on SCOMBROID FISHES towards the end of 1961.

For purposes of the symposium the various aspects of the biology and fisheries of the scombroids will be broadly dealt with under the following four major heads:—

1. Tunas.
2. Billfishes.
3. Mackerel.
4. Seer fishes.

All those interested are requested to contribute papers and participate in the discussions. For further particulars please write to :—

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Symposium,
Marine Biological Association of India,
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DUGONG RESEARCH AND CONSERVATION FUND

The kind attention of all animal lovers is invited to the announcement made in Volume I, No. 2 of the Journal regarding the starting of the DUGONG RESEARCH AND CONSERVATION FUND under the auspices of the Marine Biological Association of India for the study and conservation of the Sea-cow or Dugong. Contributions to the above Fund may please be sent to the Treasurer, Marine Biological Association of India, Marine Fisheries P.O., Mandapam Camp, South India.

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* * * * *

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* * * * *

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For the convenience of the various educational institutions interested in conducting field studies on the marine fauna and flora, the Marine Biological Association of India, with its headquarters at Mandapam Camp, has organised a Marine Biological Service in an endeavour to assist *institutional members* in organizing educational tours to the places of marine biological and fishery importance. The various Educational and Research Institutions and the different Universities in India are invited to avail of the service offered by the Marine Biological Association of India.

* * * *

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Journal of the
Marine Biological Association of India

ABBREVIATION : *J. Mar. biol. Ass. India*

VOL. II June 1960 No. 1

VITIAZ EXPEDITION TO THE INDIAN OCEAN*

By R. RAGHU PRASAD

Central Marine Fisheries Research Station, Mandapam Camp

'*Forasmuch as the main ocean is the Lord's alone, and by nature left free for all men to deal withal, as very sufficient for all men's use, and large enough for all men's industry.*'

—DRAKE'S VOYAGE.

THE Indian Ocean covering an area of about 28,000,000 square miles constitutes more than 14% of the earth's surface. Except for the general features of its bottom topography, circulation, water masses and the distribution of its biota, little is known. More than half of this region has had no biological sampling and even in the areas sampled data are only on 1 to 4 observations per 100,000 square miles. As part of the IGY programme to explore the Indian Ocean, the Soviet Union agreed to send an expedition and on October 6, 1959, the Flagship of the Soviet Scientific Research Fleet *Vitiaz* left Vladivostock on her 31st cruise since commissioning as a research vessel and her first to the Indian Ocean.

Before World War II, *Vitiaz* was a German cargo-cum-passenger liner. After the Soviet Union acquired the ship she was transferred to the Institute of Oceanology, U.S.S.R. Academy of Sciences, for its use as a research vessel and in 1949 remodelling was completed. This is the world's largest research vessel and is well equipped for carrying out investigations on all aspects of oceanography. *Vitiaz* is a 5,700-ton diesel vessel with a maximum speed of 14 knots and a cruising range of 18,500 miles. She can accommodate 70 scientists, has a crew of 66 and can carry provisions, fresh water, etc., sufficient for her full complement of 136 persons for 120 days. There are 14 laboratories, viz., hydrology, hydrochemistry, biochemistry, geology, geochemistry, plankton, ichthyology, benthos, isotope, physics, acoustics, electroc-mechanical, marine technical and meteorology laboratories. In addition there is a library, a photographic dark-room and adequate space for storage of scientific equipments and materials collected during the expeditions. Further

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details regarding the ship and her equipments are available in the account of *Vitiaz* by Sysoev (1959).

The aims of the expedition were the study of circulation and distribution of currents ; characteristics of zones of fronts ; temperature balance between water layers and atmosphere ; carbon dioxide in ocean and atmosphere and monitoring changes ; optical properties of sea water ; relief and sedimentation ; suspended particles, cosmic dust, etc. ; chemical processes in the sea ; distribution of fish, plankton and benthos ; primary production ; complex and characteristics of geographical zones of the ocean ; natural radioactivity of sea water, animals and sediments ; development of instruments and methods for studying oceans ; and contact with foreign scientists and organizations.

Invitations were sent to countries bordering the Indian Ocean to participate in the expedition. Government of India accordingly deputed 3 scientists who participated in the cruise to the western half beginning with Cochin.

Figure 1 shows the route of *Vitiaz* with the location of stations. It will be noticed that a vast area was covered and a total of 221 stations were worked up to the time the ship called at Bombay. After a few days' stay at Bombay *Vitiaz* proceeded to Odessa and on her way back to Vladivostock sometime during September-October this year she is scheduled to work in the Arabian Sea and Bay of Bengal thereby covering practically the entire Indian Ocean. Several expeditions have earlier worked in the Indian Ocean but *Vitiaz* has carried out by far the most extensive and intensive work in this area. Plates I and II show the expedition ship *Vitiaz*, some of her equipments and the benthos laboratory.

The following account of the activities of the expedition is based on the experience of the author during the cruise between Cochin and Bombay when data were collected from 97 stations. Throughout the cruise continuous measurements of depth were made to study the bottom contour and at all stations hydrological observations formed an essential part. The time spent at each station varied from 23 minutes to about 32 hours. The programme of work also varied from station to station but at all stations work began with the measurnment of temperature gradient using a bathythermosound. The instrument can be operated up to 200 meters and is considered to be more sensitive than a bathythermograph. The temperature is recorded in the laboratory on board on suitably graduated paper. In general, the work at ' standard stations ' included temperature measurements and collection of water samples from standard depths for chemical, hydrological and geological analyses ; collection of water samples in special plastic bottles from selected depths for the study of optical properties and phytoplankton and measurements of currents from the fore and aft of the ship with the aid of Alexeev current meters. A single vertical haul from the bottom to the surface was taken with a ring trawl for collecting fish eggs, larvae, etc. Sometimes the ichthyo-plankton net also was employed for this purpose. For general plankton studies stratified vertical hauls usually from 300-200, 200-100, 100-50, 50-25, and 25-0 metres were taken with the aid of Juday type closing net. From 100-0 metres two samples with the same net were taken for the study of the chemical composition, total biomass, oil content of plankton, etc. Plankton collecting devices on board included the ' plankton catcher ' designed by Prof. B. G. Bogorov of the Institute of Oceanology. It filters 20 litres of water and is especially useful for the study of vertical distribution of plankton in relation to thermocline and also for collecting quantitative plankton samples from small boats.

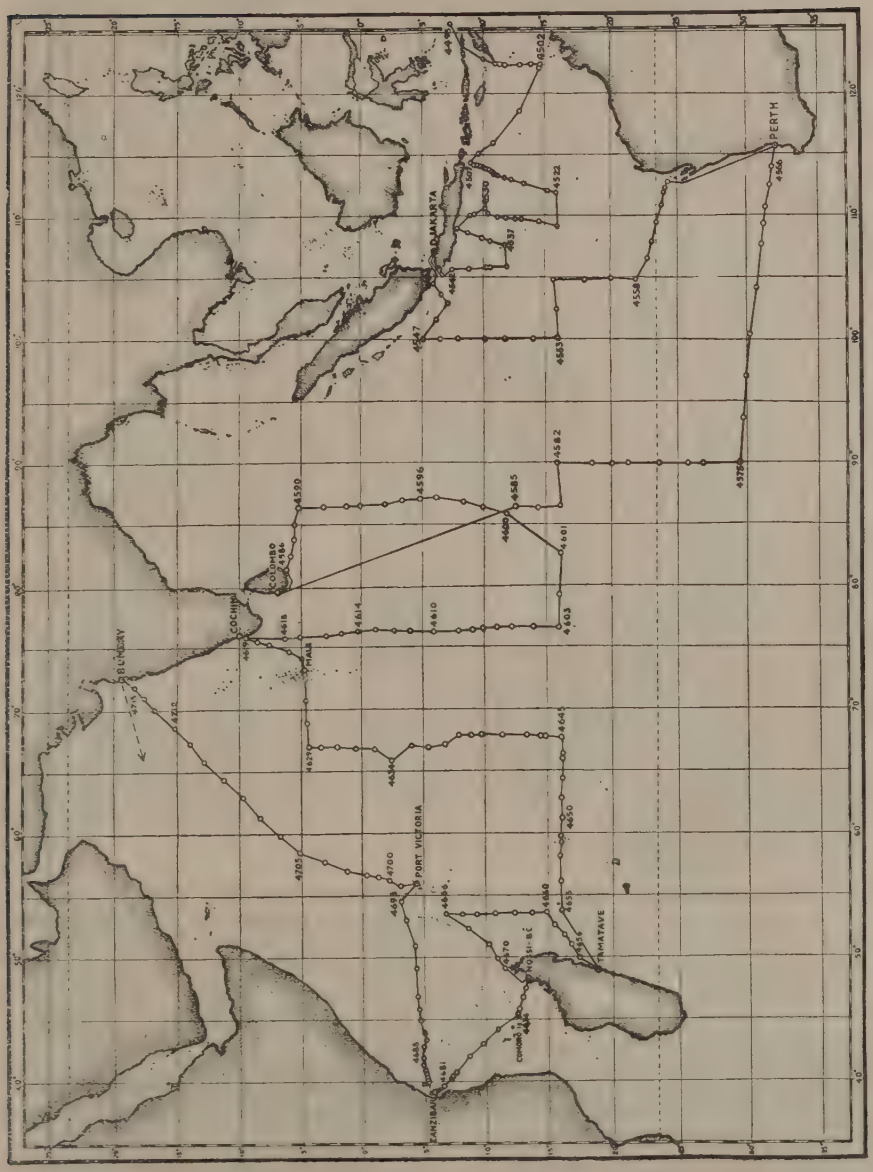

FIG. 1. The route of *Vitiaz* with the location of stations.

Besides, collection of bathypelagic animals, benthos, sediments and measurement of organic production were conducted at many stations. The bottom fauna were generally collected with a grab. *Galathea* and Sigbee trawl, with devices for measuring the distance trawled, were also employed for the purpose. An ordinary otter trawl was used but only on two occasions. The Isaacs-Kidd mid-water trawl with an acoustical device for recording the depth at which trawling was done, and a big conical net were occasionally used for collecting the larger bathypelagic organisms. Core sampling with the aid of gravity or piston corers was carried out at several stations and in addition seismo-acoustical methods were employed at a series of stations off the coast of Zanzibar to study the sediments. Measurements of organic production by the use of ^{14}C were periodically done at standard depths up to 200 metres. The experiments were generally conducted on board in specially designed barrels but in order to check the values obtained from these, *in situ* measurements at different depths were made occasionally using a series of special plastic clear- and dark-bottles. These bottles are constructed in such a way that when the messenger strikes the closing device, it closes the two ends of the bottle traping a known quantity of water and the upper lids while closing release the ^{14}C kept in a small pipette on the side of each bottle. This arrangement obviates the need to bring on board water samples collected from various depths for adding ^{14}C and then lowering the bottles to the appropriate depths, and thereby eliminates the possibility of subjecting the water samples to different temperature and light conditions. The bottles were left in the sea for 6 hours and then taken on board for estimating the amount of carbon assimilated.

At a few stations photographs of the sea bottom were taken using a deep sea camera. The camera used on *Vitiaz* is designed to expose 20 frames at a time without bringing the camera on board. With its normal lens and at 45° an area of 2.5 m^2 is covered from a distance of 2 metres. When greater areas are to be photographed a wide angle lens is used.

It was mentioned earlier that current measurements were made at every station but the duration of such measurement was relatively short, not exceeding 5 or 6 hours. Therefore at 6 stations continuous measurements were made for 24 hours and at one station for 12 hours. At these stations current meters were suspended at different depths up to 1,000 meters from an anchor buoy weighing about 2 tons and made out of a synthetic compound ' Penoplast '.

The meteorological division, with an up-to-date meteorological laboratory, was engaged in studying various problems in marine meteorology. Radio-sondes were used periodically to obtain temperature, pressure, humidity and wind velocity data from the upper air strata. Daily synoptic charts were also prepared and weather forecasts issued.

In the organization, co-ordination and execution there was the characteristic thoroughness and even the smallest details were given careful consideration. During expeditions of this magnitude one would expect accidents, disappointments and losses but such instances were indeed rare. Another noteworthy feature of the expedition was in the analyses and processing of data collected. It is often the experience that processing of the data and even some of the analyses will necessarily have to wait until the materials are brought back to the shore laboratories. This is because in most research vessels there will be only one or two small laboratories and provision

FIGS. 1. Soviet expedition ship *Vitiaz*, 2. The trawl winch, 3. The damping device or accumulator used with the trawl winch, 4. The deep sea camera, 5. Plastic dark- and clear-bottles used in ^{14}C experiments. The arrow shows the small pipette carrying ^{14}C, 6. The 'anchor buoy' 7. Submarine photometer.

Figs. 8. The big conical net, 9. The gravity corer, 10. The bathythermosonde, 11. Hydrographic winches and the rack with reversing water bottles, 12. The benthos laboratory 13. The plankton net ready to go down, 14. Prof. Bogorov with the 'plankton catcher'. 15. Alexeev current meters.

for the accommodation of the scientists is limited to a few. As work at sea proceeds round the clock it is difficult for these few to attend to the collection, analyses and processing of the materials collected. In *Vitiaz* most of the analyses and processing, particularly the chemical, physical and hydrological data were done on board, for she was a magnificent floating laboratory.

During the cruise from Cochin to Bombay the ship called at Male (Maldives), Tamatave and Nossi-Bé (Madagascar), Dzaoudzi (Comoro Islands), Zanzibar and Port Victoria in the Seychelles.

The results of this expedition will substantially add to our knowledge of this vast and little known area. The tropical and sub-tropical regions bordering the Indian Ocean have many of the world's densely populated countries. Population pressures on the existing food supplies result in the prevalence of protein deficiency diseases in these countries and the best way to combat these will be to expand their fisheries. India herself is vitally concerned with these problems and with her long coastline, a sea-faring tradition and rich fishery potentials, scientific knowledge of the seas around us will have direct and immediate bearing on our expanding marine fisheries. Many of us cherish the hope that before long our country too will be sending out expeditions, though not of the same magnitude as that of *Vitiaz*, to explore the waters around us and thus take her rightful place among the countries more advanced in marine biological and oceanographic research.

Acknowledgement

The author takes this opportunity to express his grateful thanks to Prof. Dr. B. G. Bogorov, the Leader of the Expedition, Captain I. V. Sergeev and all other members of the Expedition for their kindness and many courtesies.

Reference

Sysoev, N. N. 1959. Soviet expedition ship '*Vityaz*.' *Année Géophysique Internationale, Moscow*, pp. 32 (in Russian).

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AN ACCOUNT OF THE STRUCTURE AND EARLY DEVELOPMENT OF A NEW SPECIES OF A NUDIBRANCHIATE GASTROPOD, *EOLIDINA* (*EOLIDINA*) *MANNARENSIS**

By K. Virabhadra Rao & K. Alagarswami

Central Marine Fisheries Research Station, Mandapam Camp

Introduction

A small nudibranch of the family Aeolidiidae was at first obtained in the month of March 1960 from a collection of squid eggs attached to weeds in a shallow water region of the Gulf of Mannar in the vicinity of the Central Marine Fisheries Research Station at Mandapam. Subsequently the same form was found to occur in fairly large numbers creeping over the sides of some large aquaria with circulating sea water in the Research Station. The glass panes of the aquaria were kept not cleaned thereafter which promoted a vigorous growth of a few sedentary organisms like the hydroids, colonial ascidians and polychaetes amidst which the nudibranchs thrived well depositing strings of their spawn. This form has been referred to the genus *Eolidina* Quatrefages, sub-genus *Eolidina* and described as *E.* (*E.*) *mannarensis*, a species new to science. The opportunity presented by the availability of freshly laid spawn in the aquaria has enabled studying some aspects of the life-history of the species.

We have great pleasure in expressing our gratitude to Dr. S. Jones, Chief Research Officer of the Central Marine Fisheries Research Station, for his kind encouragement and valuable suggestions during the course of this study. Our thanks are due to Dr. R. Raghu Prasad for rendering translation of relevant passages of German references into English.

External Features of *Eolidina* (E.) *mannarensis* sp. nov.

The general appearance of the animal is aeolidiform. The head is anteriorly rounded with its lateral extremities produced into a pair of long, smooth tentacles broad at the base and narrow at the distal end. A little behind the region of the tentacles is a pair of smooth rhinophores without any distinct perfoliations but presenting a slightly ringed appearance when they are contracted. Close behind the base of each rhinophore is a minute dark pigmented spot representing the eye situated internally but visible through the transparent skin covering it. The head region in front and behind the rhinophores is narrow and is continued by an expanded dorsum, which bears on either side groups of linear cerata extending upto the region of the tail. About 6 or 7 of the anteriormost cerata on either side are grouped into a distinct cluster behind which is a little gap followed by other clusters

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not distributed in a well-defined manner. The cerata are circular in cross section and the digestive diverticula entering into them are unbranched. The latter are in communication with tiny cnidosacs which open to the exterior at the free ends of the cerata. The posterior region of the animal is produced into an elongate tapering tail. The foot is considerably broader than the dorsum. In the anterior region the former is broadly rounded and produced into a triangular flattened expansion on either side. The mouth opening is median and ventral in the head. The male genital opening in front and the female genital opening a little behind are situated beneath the level of the anteriormost group of cerata of the right side. The anal aperture is also on the right side about the level of the cerata at half the length of the animal. The general colouration is pale golden yellow speckled with orange at the tips of the tentacles and rhinophores. Faint orange colouration is present over the surface of the cerata and the dorsum on which it is more prominent in the anterior region than behind. The tips of cerata in the region of the cnidosacs are slightly whitish. The digestive diverticula of the cerata seen through the transparent lining epithelium are grayish brown. The foot appears uniformly yellowish white.

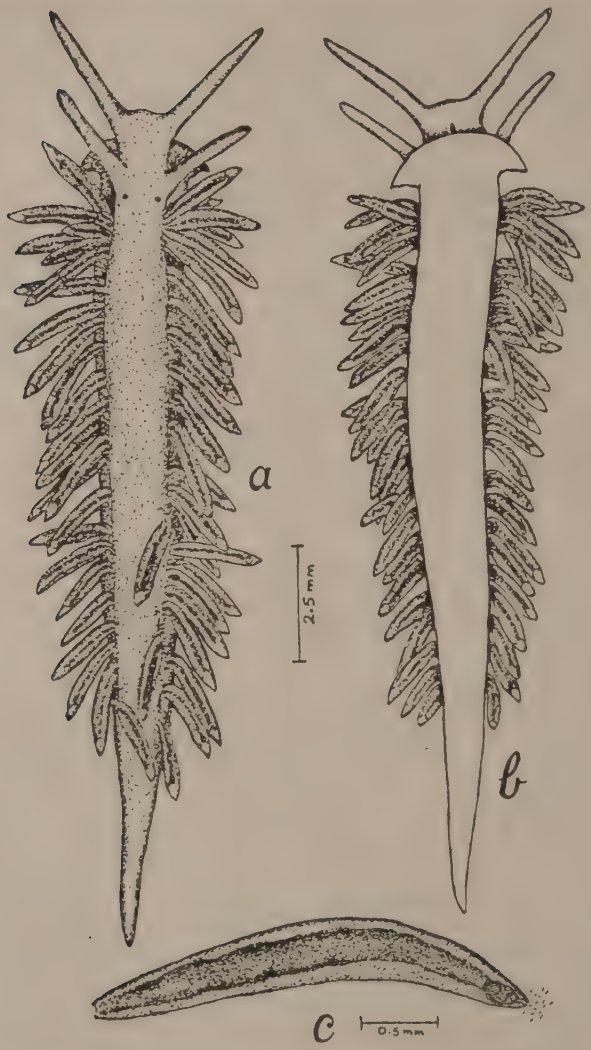
A full-grown animal has a length of 20 mm. including the tentacles when fully expanded and found creeping. The tentacles and the rhinophores are 3 mm., the cerata about the same and the tail 6 mm. in length. In the region of the first group of cerata the foot has a width of 2.2 mm. and the dorsum 1.5 mm. (Text Fig. 1, *a*, *b* and *c*).

Internal Organs of *E.* (*E.*) *mannarensis* sp. nov.

The structure of the internal organs has been studied from dissections under the magnification of the binocular microscope and also from stained preparations of transverse serial sections.

The digestive organs consist of a slit-like mouth leading into a small, highly muscular pharyngeal bulb, a narrow short oesophagus, a much enlarged stomach, a ramified system of digestive diverticula extending into the cerata, a short intestine and a rectum opening by the anus. The jaws are thin, chitinous, more or less triangular, hinged together in the region of the beaks and produced into cutting edges opening into the mouth. They measure about 450 μ along the long axis (Pl. I, fig. 1). The radula is short with about 11 well-developed teeth and a few others in the process of formation in the radular sac. They are broad, arched, each with an abbreviated median cusp and about 11 sharp lateral cusps mounted on an expanded wing on either side (Pl. I, fig. 2). The median cusp being small and the lateral portions very prominent, the tooth presents the appearance of two distinct halves, a feature which is very characteristic of the genus. Of the lateral cusps the first three close to the median one and the last in the series are much shorter than others. The functional teeth on the radula measure each 80 μ broad in the widest region. The general arrangement of the various organs of digestion and the disposition of the pharyngeal (ptyaline), salivary and hepatic glands are very similar to those found in most members of the family Aeolidiidae (Pl. I, figs. 3 & 4). These forms presumably feed on hydroids of which *Zanclea indica* occurred in fair abundance wherever they were found on the glass panes of the aquaria.

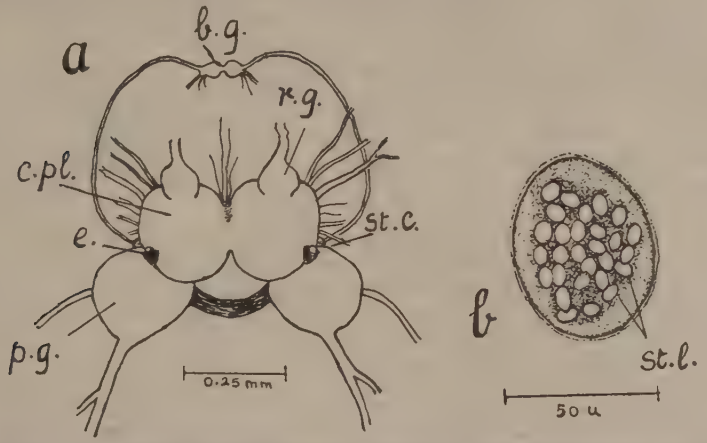
The central nervous system (Text Fig. 2 *a*) shows mainly a pair of cerebropleural and a pair of pedal ganglia, the former being situated close together pressing against



TEXT FIG. 1. *a*. Dorsal aspect of *Eolidina* (*Eolidina*) *mannarensis* sp. nov. ; *b*. Ventral aspect of the animal ; *c*. A single cerata magnified showing the discharge of the contents of the cnidosac under slight pressure.

the posterior region of the pharyngeal bulb and dorsal to the oesophagus. The pedal ganglia are situated a little behind and below the cerebropleural ganglia. There are also paired rhinophoral ganglia in close association with the antero-dorsal

region of the cerebropleural ganglia, and paired buccal ganglia in the posterior region of the pharyngeal bulb ventral to the oesophagus. The commissures and connectives are similar in arrangement as in *Cuthona adyarensis* (Rao, 1952). Eyes are well developed each with a crystalline lens and a pigmented retinal cup. Paired statocysts contain several statoliths in each (Text Fig. 2 *b*).



TEXT FIG. 2. *a*. Central Nervous System of *Eolidina* (*E.*) *mannarensis* sp. nov. ; *b.g.*—Buccal ganglion ; *c.pl.*—Cerebro-pleural ganglion ; *e.*—Eye ; *p.g.*—Pedal ganglion ; *r.g.*—Rhinophoral ganglion ; *st.c.*—Statocyst ; *b*. Statocyst magnified with *st.l.*—Statolith.

The heart, enclosed in the pericardium, has a single auricle and a single ventricle, placed dorsally behind the region of the stomach. The kidney is ventral to the pericardium and extends to some distance behind the region of the heart immediately beneath the body-wall. The anterior diverticulum of the kidney communicates with the pericardium and the rectum as revealed by the serial sections (Pl. I, fig. 5).

The follicles of the hermaphrodite gland are compactly packed behind the region of the heart occupying much of the body space upto the root of the tail (Pl. I, fig. 6). They have usually the male acini in the centre and the female acini at the periphery. The outgoing ducts from different follicles join into a median hermaphrodite duct which leads into an anterior genital complex. The hermaphrodite duct communicates distally with the male and female parts of the reproductive system. The former consists of a seminal ampulla, a wide coiled prostate gland, a narrow ejaculatory duct and an eversible penis in the penis sheath opening to the exterior by the male genital aperture, whereas the latter has an oviduct with a fertilisation chamber communicating with the muco-albuminous glandular passage leading out to the exterior by a short vaginal tube. The eversible penis in *E.* (*E.*) *mannarensis* is not provided with a stylet.

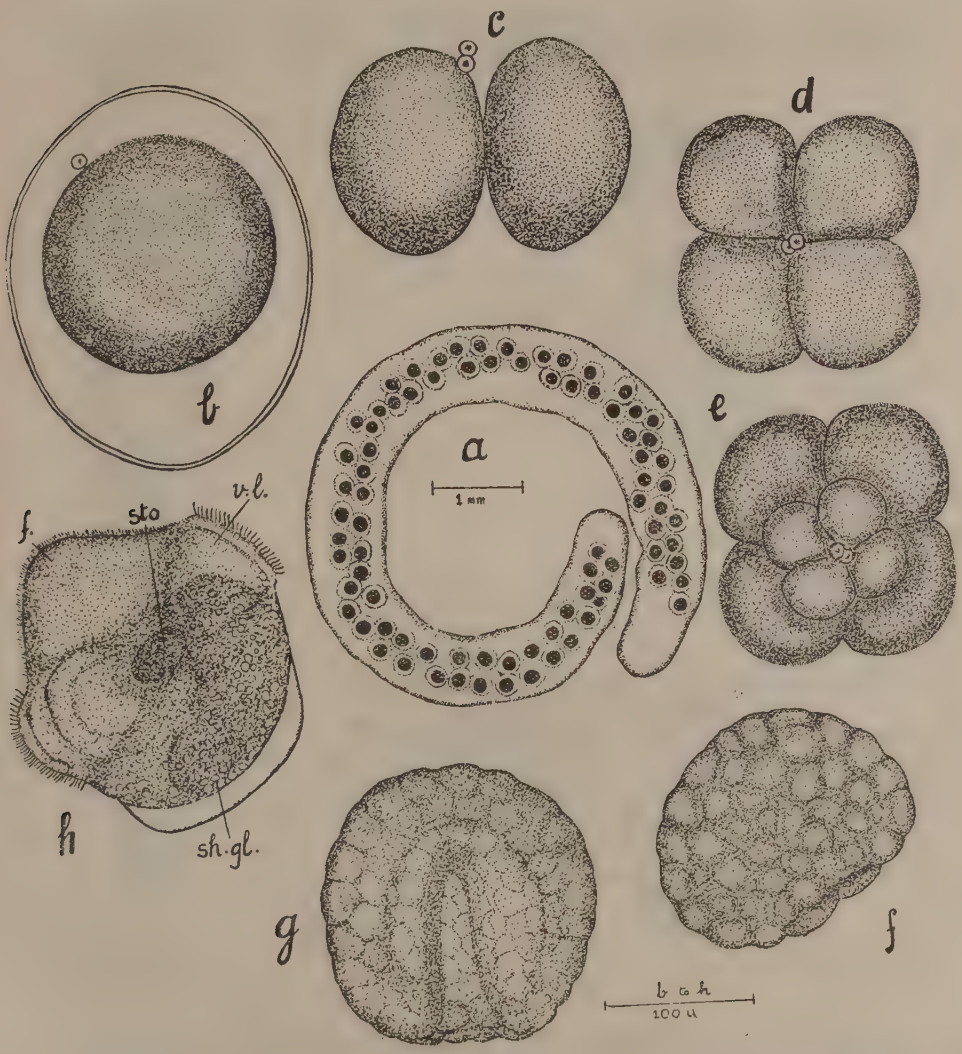
EARLY DEVELOPMENTAL STAGES OF *E.* (*E.*) *mannarensis* sp. nov.

In the aquaria the copulating pair of individuals was observed to approach in opposite directions with the anterior right regions coming close together, so that the male genital aperture of one opposes the female genital aperture of the other. The

duration of copulation lasts for a brief time of about a minute. Fertilization is internal. After the separation of the copulating individuals, each deposits a mucilaginous string of spawn which is either crescentic or spiral in appearance measuring about 0.8 mm. in diameter and 12 mm. in length (Text fig. 3 *a*). Large numbers of such strings of spawn were collected from the glass panes of the aquaria or from the sides of the finger-bowls in which the animals were kept under observation. Each string has about 80 to 200 eggs. When freshly deposited the egg is spherical, yellowish in colour and heavily yolk laden measuring 150 μ in diameter. It is enclosed in a spacious double-walled capsule either slightly or prominently oval, about 240 μ in the longest axis (Text fig. 3 *b*). The space between the capsule and the egg is filled with a colourless albuminous fluid. The following account is based on the development of the eggs in freshly deposited spawn kept in finger-bowls holding sea water having a varying range of salinity from 33.53°/$_{oo}$ to 34.18°/$_{oo}$ and a temperature from 29° C to 31° C.

Fifty minutes after the oviposition the first polar body is seen to extrude out and it is followed by the formation of the second polar body. The first cleavage which takes place 2 hours and 30 minutes after the oviposition is vertical dividing the egg into two exactly similar halves (Text fig. 3 *c*). The second cleavage about 4 hours after the first, is also vertical but at right angles to the first, resulting in four large cells (Text fig. 3 *d*). One hour and thirty minutes thereafter, the third cleavage takes place in the horizontal plane resulting in eight cells of which four are large and four others small, the megameres and micromeres respectively (Text-fig. 3 *e*). By about 18 hours segmentation has progressed far so as to form a blastula. The micromeres, dividing a little more rapidly than the megameres, spread over the latter (Text-fig. 3 *f*). Following this stage in development there is gastrulation partly by epiboly and partly by invagination (Text-fig. 3 *g*). At this stage the blastopore is clearly visible in the developing embryo. Later the blastopore is reduced and finally closed. A stomodaeal depression appears at the place where the blastopore has closed. It extends inwards and meets the enteric space. The antero-lateral regions of the embryo in the stomodaeal region enlarge and get demarcated into velar lobes with vibratile cilia. The region ventral to the stomodaeal depression expands into the primordium of the foot, the surface of which is covered by numerous delicate short cilia. In the aboral region the shell gland is formed secreting the larval shell. (Text-fig. 3 *h*). At this stage which results in about 50 hours after the oviposition, the embryo begins to rotate with the help of the velar cilia.

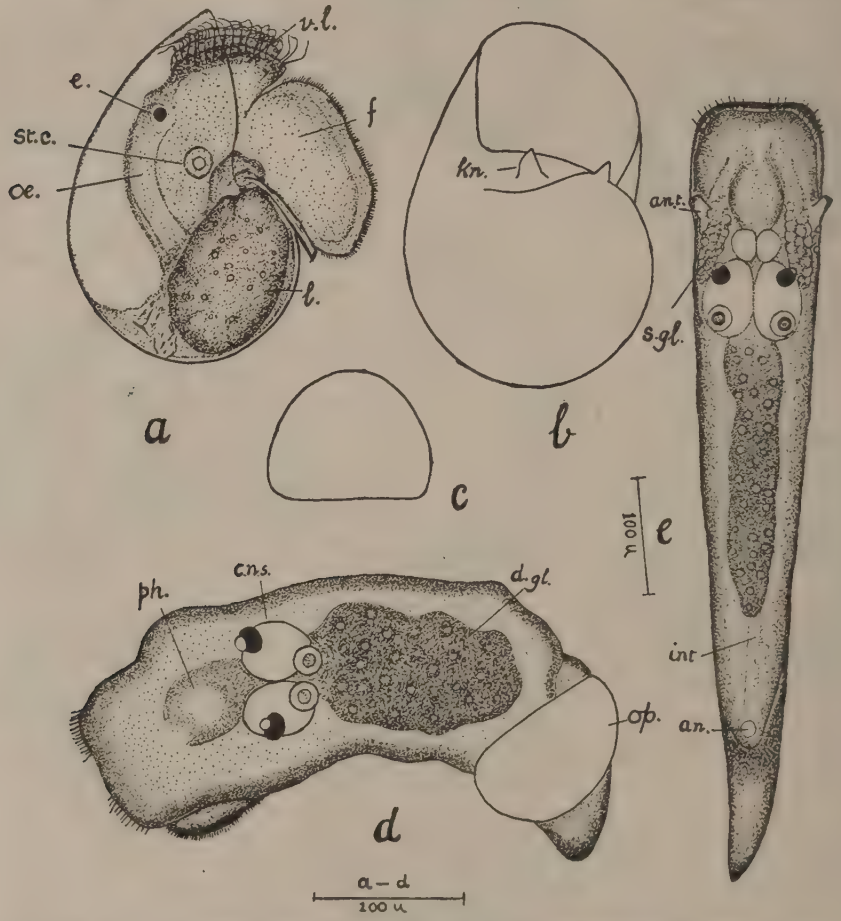
In 72 hours since the development has commenced, a fully formed veliger results (Text-figs. 4 *a*, *b*, & *c*). It has an ovoid shell the aperture of which is provided with a close fitting operculum. The shell structure is smooth, transparent and colourless. A very striking feature of the shell of the present form is the presence of two small peg-like projections in the region below the lower margin of the aperture. The shell measures about 230 μ in the longest axis. The soft body encased within the shell has a moderately expanded bilobed velum with powerful cilia situated dorsally and a broad median foot fringed with delicate cilia placed ventrally. Close behind the origin of the velar lobes is a pair of dark pigmented eyes and ventrally at the base of the foot are the paired statocysts. The mouth opening between the velar lobes and the foot leads into a narrow oesophagus which expands into a broad stomach at the posterior region of the shell. The intestine following the stomach runs forwards and is continued by an abbreviated rectum which opens into the mantle space. The liver mass is large, rather greenish



TEXT FIG. 3. *a*. Freshly laid spawn of *Eolidina* (*E.*) *mannarensis* ; *b*. Egg with the polar body just extruded ; *c*. Two-cell stage ; *d*. Four-cell stage ; *e*. Eight-cell stage ; *f*. Blastula ; *g*. Gastrula ; *h*. Early veliger : *f*.—Foot ; *sh.gl*.—Shell gland ; *sto*.—Stomodaeum ; *v.l*.—Velar lobe.

and bilobed in appearance. At the posterior region of the shell are visible the retractor muscles of the velum. The fully formed veligers have been observed to move vigorously within the egg capsules for a considerably long time before they are

liberated at the end of the eighth day. The larva has only a short duration of pelagic life lasting about 24 hours after which it has been observed to settle down at the bottom and creep with the help of the fully expanded foot. The velar lobes undergo



TEXT FIG. 4. *a*. Freshly hatched veliger of *Eolidina* (*E.*) *mannarensis* ; *e*.—Eye ; *f*.—*Foot* ; *l*.—*Liver* ; *oe*.—Oesophagus ; *st.c*.—Statocyst ; *v.l*.—Velar lobes. *b*. Empty shell ; *kn*.—knob-like projection ; *c*. Operculum ; *d*. Early stage short creeping form with operculum still attached : *c.n.s*.—Central nervous system ; *d.gl*. —Digestive gland ; *op*.—Operculum ; *ph*.—Pharynx ; *e*. Late stage of creeping form with elongate body : *an*.—Anal aperture ; *an.t*.—Anterior tentacle ; *int*.—Intestine ; *s.gl*.—Salivary gland.

a gradual diminution in size. The internal organs are squeezed out as it were from the shell and the operculum is dropped. Often the creeping form devoid of shell may still be seen dragging the operculum attached to the posterior region (Text-fig.

4 *d*). The earliest creeping stage about 350 μ long is rather clumsy-looking, short and a bit stumpy bearing traces of the velar cilia in front, a distinct mouth opening leading into an expanded pharyngeal bulb, paired ganglionic swellings behind the latter, dark pigmented eyes on either side and a pair of very clear transparent statocysts each containing a single statolith. Behind the ganglionic swellings is the greenish mass of the liver. It is devoid of pigmentation which is characteristic of *Embletonia pallida* (Rasmussen 1944). Within a day after this stage the young one has become distinctly long about 680 μ, and assumed more or less a flattened appearance resembling a planarian. By now the rudiments of the oral tentacles have been formed, the rhinophoral ganglia in the central nervous system have been demarcated, the mass of liver has very much elongated and an intestine makes its appearance with an anal opening situated posteriorly. No further changes were, however, observed even though they survived for about a week in the glass bowls in which they were reared. In spite of frequent changes of water in the bowls ciliates in large numbers appeared attaching themselves on the young ones and smothering them. Before any further development could take place all the forms gradually perished. Under artificial conditions the non-availability of the specific items of food of which so little is known is one of the reasons for the failure of the young ones to complete their metamorphosis.

Systematic Position of *E.* (*E.*) *mannarensis* sp. nov.

History of the genus Eolidina :—Alder and Hancock (1845-1855) in their Monograph on the British Nudibranchiate Mollusca included under the genus *Aeolis* a number of very dissimilar forms which were subsequently ascribed to different genera by themselves in their synopsis to the species in the appendix to their publication and also by other workers. Thus the forms originally described as *Aeolis angulata*, *Ae. alderi*, and *Ae. glauca* were ascribed to the genus *Aeolidiella* Bergh with the following characteristics as given by Eliot (1910 a) : ' Body somewhat elongate and depressed. Cerata somewhat flattened. Corners of the foot produced into short processes. Rhinophores not perfoliate but sometimes wrinkled or furrowed. Jaws not denticulate. Teeth pectiniform, but divided into two halves with more or less developed median denticle. Ptyaline glands present.' Under the family Aeolidiidae and sub-family Eolidinae the generic name *Eolidina* Quatrefages 1843 has undoubted priority over *Aeolidiella* Bergh 1867, both being identical (Thiele 1931). The closely allied genera, viz., *Spurilla* Bergh 1864 and *Berghia* Trinchese 1877 are now being considered as subgenera under *Eolidina*. In all, the genus has three sub-genera, *Eolidina s.s.* in which the rhinophores are without perfoliations *E.* (*Spurilla*) in which the rhinophores are perfoliated and *E.* (*Berghia*) in which the rhinophores are perfoliated and also bear small knobs.

Specific characters of E. (*E.*) *mannarensis sp. nov* :—Body is aeolidiform; head bears a pair of tentacles and a pair of rhinophores of which the latter is slightly ringed when contracted ; dorsum is bare along the middle but with linear cerata in loosely arranged clusters on either side ; foot in front is broadly rounded with triangular lateral expansions and is drawn behind into a tapering tail ; anus is dorsolateral on the right side about the middle of the length of the body ; cutting edges of the jaws are without any trace of denticulation ; radula is uniseriate with about 11 to 14 teeth, each with a short median cusp and two lateral expansions bearing on either side about 12 acute cusps of which the inner ones adjoining the median one

and the last are smaller than the rest; statocysts are with several statoliths in each; penial armature is absent and general colouration is golden yellow, speckled with light orange on the dorsum, tentacles, rhinophores and cerata.

Type locality: Indian Ocean, Gulf of Mannar near Mandapam.

E. (*E.*) *mannarensis and other species under the genus :—E.* (*E.*) *mannarensis* is distinguishable from the members of the sub-genera, *Spurilla* and *Berghia* in the nature of the rhinophores as described earlier. Of the Atlantic and Mediterranean nudibranchs under the genus, *E.* (*E.*) *glauca* (A. & H.) from Torbay is characterised by the body being pale red and the branchiae stout, depressed, vermicular, tapering towards the apex, sage-green, speckled with brown and white, frequently with reddish tinge near the apices and their rows extending forwards round the base of the rhinophores. *E.* (*E.*) *alderi* (Cocks) from Falmouth has a body with opaque white spots and subconical branchiae, arranged in 12 to 14 rows extending round the head in front, the first two rows of them being opaque white and the rest gray marbled with purplish brown. In *E.* (*E.*) *angulata* (A. & H.) from Cullercoats the body is depressed terminating abruptly behind and the branchiae are in about 10 to 12 close set rows on either side, cylindrical in shape, obtusely pointed, orange red in colour with apices and surface having white blotches ; the foot is produced in front into angles at the sides and tapers suddenly behind into a fine point. *E.* (*E.*) *sanguinea* (Norman) has an attenuated body and numerous transverse rows of branchiae having blood red colouration (Alder & Hancock 1845-1855 and Eliot 1910 a). In *E.* (*E.*) *occidentalis* (Bergh) the general colouration is grayish brown with whitish lines running almost parallel to one another, transversely on the head and the back but vertically on the neck and the sides (Engel 1925). The radular teeth in *E.* (*E.*) *glauca* and *E.* (*E.*) *alderi* with numerous cusps in the lateral halves as given by Alder and Hancock (1855, Pt. 7, Pl. 47 Sup., figs. 5 & 6) are different from those met with in *E.* (*E.*) *mannarensis* which has a restricted number of cusps on their lateral expansions.

Of the species from the Pacific and the Indian Oceans, *E.* (*E.*) *orientalis* (Bergh) has a general reddish colouration of the body with elongate whitish speckles on the posterior half of the dorsum, the foot in front is rounded with a characteristic marginal furrow and the teeth resemble those of *E.* (*E.*) *glauca*. In *E.* (*E.*) *drusilla* (Bergh) the papiliary rows are free only in the anterior quarter of the back but converge behind running close to each other for the rest of the length of the dorsum In *E.* (*E.*) *indica* (Bergh) the papillary rows converge on the posterior half of the back, cerata have alternating light and dark longitudinal stripes and the radula resembles that of *E.* (*E.*) *glauca*. In *E.* (*E.*) *faustina* (Bergh) the cerata are arranged in front on a horse-shoe shaped ridge and in oblique rows behind ; the basal region of the tooth is much smaller than in other species. In *E.* (*E.*) *japonica* (Eliot), the papillary rows are simple ; the lateral halves of the teeth are unusually broad and undulating ; the middle denticle is large and the lateral denticles about 65 on each side (Engel 1925). It may thus be seen that, the present form differs from all the above species in general colouration of the body and from some of them in the arrangement of the cerata and structure of radular teeth.

Affinities :—In possessing a slender delicate build of the body, paired smooth rhinophores and tentacles, cerata being arranged in clusters on either side of the dorsum and the dorso-lateral disposition of the anus, members of the genus *Eolidina* have a superficial resemblance to those of *Cuthona* A. & H. In both the radula is

uniseriate. Yet, species of *Eolidina* are distinguishable from those of *Cuthona* upon close examination of certain external and internal characters. In the former the antero-lateral regions of the foot are expanded into triangular lobes, the cutting edges of the jaws are without denticulations and the teeth of the radula are pectinate, each with a short median cusp and broad lateral expansions on either side. In the latter the foot is rounded in front, jaws are with well-marked denticulations on the cutting edges and the tooth with a prominent median cusp and a small number of lateral cusps on either side. In the structure of the radular teeth Eliot (1910 b) finds in *Cuthona annandalei* from the Chilka Lake a certain amount of resemblance to that of *Aeolidiella* (Syn. *Eolidina*). He, therefore, suggests the probability of the dentition in *Eolidina* having been derived from that of *Cuthona*.

Summary

1. A small aeolidiform mollusc from the Gulf of Mannar in the vicinity of Mandapam has been referred to the genus *Eolidina*, sub-genus *Eolidina* and described as a new species, *E.* (*E.*) *mannarensis*.

2. A narrow dorsum, a tapering tail, a broad foot with prominent antero-lateral expansions, paired tentacles and rhinophores, the latter without distinct perfoliations, linear cerata arranged in lateral rows but not grouped into distinct clusters, jaws without denticles, pectinate radular teeth, a dorso-lateral anus, statocysts with several statoliths in each, a penis without a stylet and a general golden yellow colouration of the body speckled with orange are the salient features of the species.

3. Spawning behaviour and the early developmental stages have been observed. The first cleavage of the egg results in two cells of equal size. The succeeding cleavages follow the same pattern as in other nudibranchs. The larval shell is characterised by the presence of two peg-like projections below the lower edge of the aperture. The duration of the pelagic life of the larva is very short. The creeping form, after discarding the shell, has been described. Further stages in metamorphosis could not be followed as the young under observations perished in about a week due to lack of specific food materials and infestation by ciliates.

4. The distinctive features of the genus *Eolidina* and of its sub-genera are dealt with. A comparative account of the specific characters of the present form with those of the hitherto known species under the genus has been given. The superficial resemblances of the form with certain members under the genus *Cuthona* have been pointed out.

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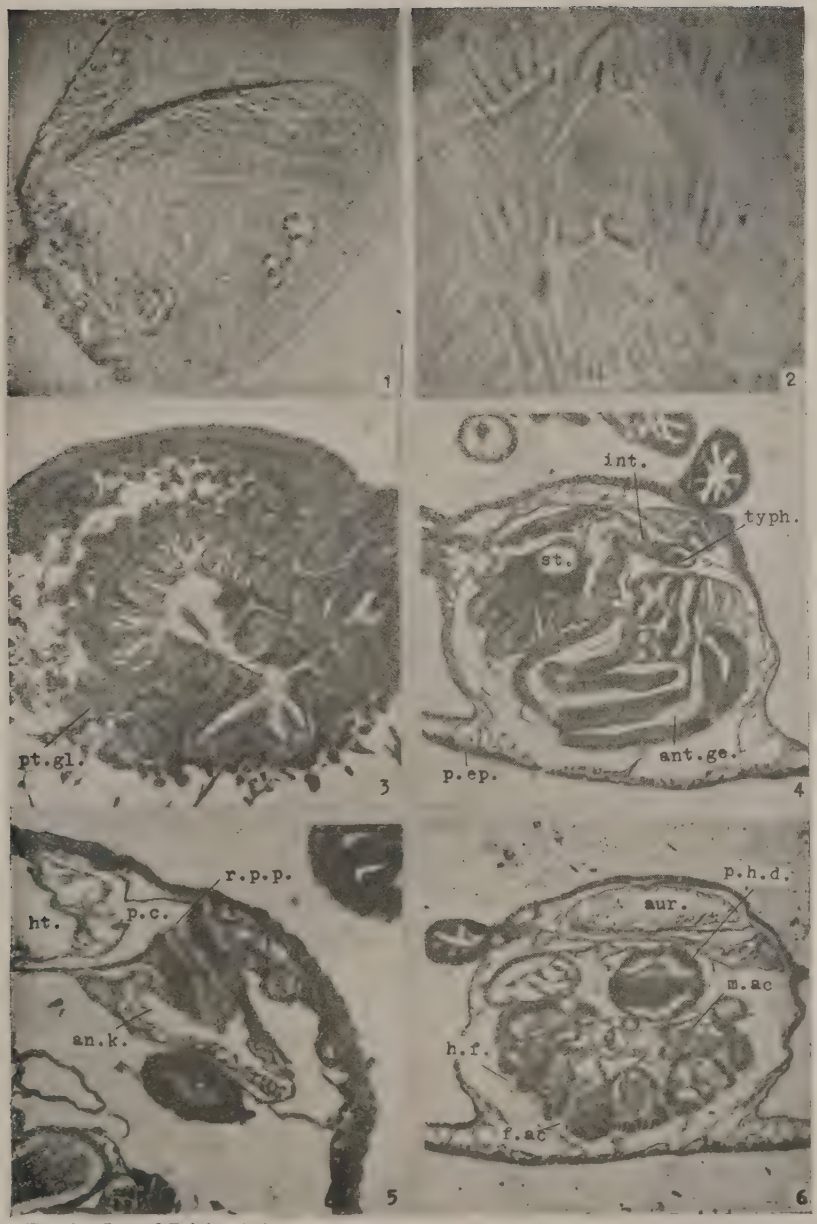

FIG. 1. Jaw of *Eolidina* (*E.*) *mannarensis* sp. nov. x 135.
FIG. 2. Radular teeth. x 550.
FIG. 3. T.S. through pharyngeal passage : *pt. gl.*—Ptyaline glands. x 140.
FIG. 4. T.S. through the region of the stomach : *ant. ge.*—Anterior genitalia ; *int.*—Intestine ; p.e.p—Pedal epithelium ; *st.*—Stomach ; *typh.*—Typhlosole. × 50.
FIG. 5. T.S. through the region of the pericardium and renal organs : *an.k.*—Anterior diverticulum of kidney ; *ht.*—Heart ; *p.c.*—Pericardium ; *r.p.p.*—Reno-pericardial opening. x 150.
FIG. 6. T.S. through the region of the hermaphrodite follicles : *aur.*—Auricle ; *f.ac.*—Female acini ; *h.f.*—Hermaphrodite follicles ; *m.ac.*—Male acini ; *p.h.d.*—Posterior hepatic diverticulum. x 50.

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OBSERVATIONS ON THE MATURITY AND SPAWNING OF *THRISSOCLES HAMILTONII* (GRAY) IN BOMBAY WATERS

By V. B. Masurekar and M. S. Rege
Institute of Science, Bombay

Thrissocles fishery in Bombay is mainly contributed by two species, namely, *T. purava* and *T. hamiltonii*, the occurrence of the other species of *Thrissocles* being rare and sporadic. Some work on the maturity and spawning of *T. purava* has been already carried out by Palekar and Karandikar (1952). An attempt is, therefore, made to study the maturity and spawning of *T. hamiltonii* which occurs in sizeable quantity along the coast of Bombay during the periods, late September to November and late March to May.

Thrissocles hamiltonii (Gray) locally known as 'Kateri' is a small fish attaining a maximum standard length of 20.0 cms., with a maximum weight of about 90 gms. The fish though tasty does not seem to suit the table delicacy of the rich as it contains numerous small bony spines in its skeleton. However, the middle and the lower class people consume this fish in large quantities.

The material for the study of maturity and spawning of *T. hamiltonii* was collected from the fish landing places along the coast of Bombay. The present work is based on the data collected during the period September 1953 to May 1954. The occurrence of this fish during the months of December and January and in June, July and August was practically negligible. The observations are based on the standard length of the fish measured from the tip of the snout to the origin of the caudal fin.

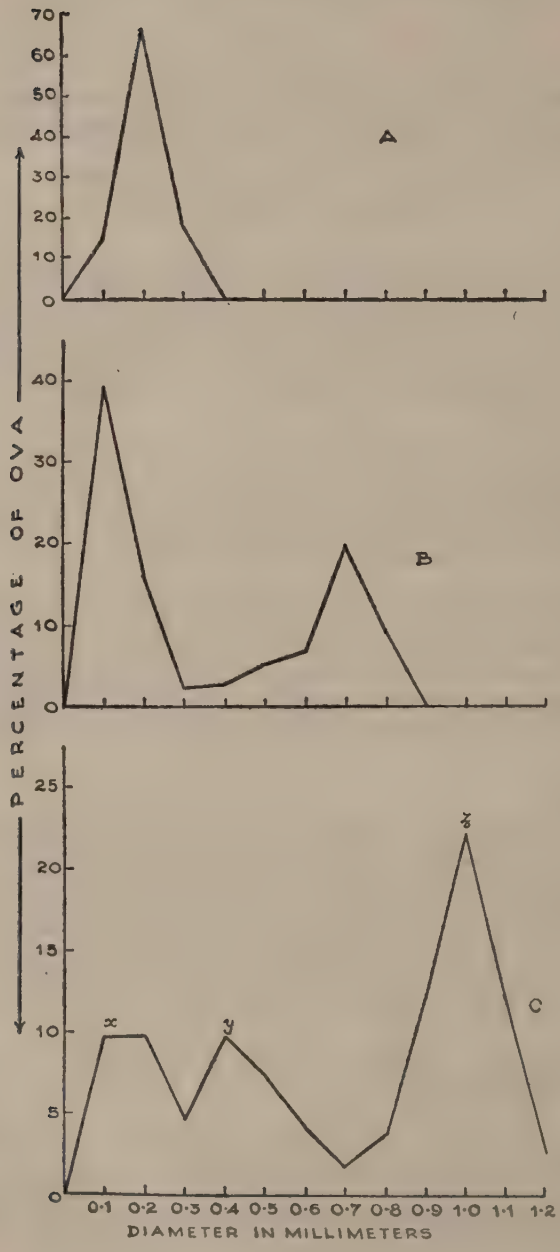
Spawning period :

A gross examination of the gonads of all the fish collected, together with the detailed study of ova-diameter measurements of selected females were made use of in determining the spawning period of the fish. The ovaries of the collected fish were preserved in 5% formalin and later on 10 ovary samples were taken for measurement of ova diameters. The distribution of ova of various sizes, in the anterior, middle and posterior part of the ovary was found to be uniform. 300 ova from each ovary were measured for estimating the size frequency percentages of the ova. Method adopted by Clark (1934) and Prabhu (1956) was utilised for this purpose.

As a result of this study three stages in the development of the eggs in the ovary, are recognised (Fig. 1).

(1) The immature eggs upto 0.30 mm. in diameter constitute stage I. The fish with such an ovary is termed here as *immature* ;

(2) The maturing eggs ranging from above 0.30 mm. to 0.80 mm. in diameter constitute stage II. The fish with the predominance of such eggs in the ovary is called *maturing*, and finally,


70
60
50
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A
40
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25
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15
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x
y
z
C
PERCENTAGE OF OVA
0·1 0·2 0·3 0·4 0·5 0·6 0·7 0·8 0·9 1·0 1·1 1·2
DIAMETER IN MILLIMETERS

FIG. 1

(3) The matured eggs measuring more than 0.80 mm. in diameter represent stage III. Such a fish with ovary containing numerous mature eggs is termed as *mature.*

It has been mentioned at the outset that *T. hamiltonii* is found in sizeable quantities during the periods late September to November and late March to May. A study of the adult females during these periods shows that a large majority of the fish is either in mature or spent condition as shown in Table A giving the percentage of females in each stage of maturity. From this it can be inferred that the fish has two distinct spawning seasons one from October to November and the other from late March to May.

Incidentally it may be mentioned here that the plankton collections made in connection with the study of fish larvae and post-larvae of Bombay waters since 1952 to 1954, contained many post-larval forms of *T. hamiltonii*, ranging from 14 mm. to 22 mm. in size, during May and early June, and November.

A careful examination of the frequency polygon of the mature ovary (Fig. 1C) reveals that this ovary contains a distinct stock of mature ova (mode at z) and two other stocks of immature (mode at x) and early maturing (mode at y) eggs

TABLE A

Percentage of females in each stage of maturity

Stage of Maturity	Sept.	Oct.	Nov.	April	May
Immature	5	14	6	8	20
Maturing	60	22	14	32	15
Mature	35	27	41	40	25
Spent	—	37	39	20	40

TABLE B

Number and percentage of mature and spent females in each centimeter length group

Length in cms.	No. of fish observed	No. of mature and spent individuals	Percentage of mature and spent individuals
11.5—12.5	22	—	—
12.6—13.5	13	—	—
13.6—14.5	15	1	6.7
14.6—15.5	14	8	57.1
15.6—16.5	26	22	84.6
16.6—17.5	40	36	90.0
17.6—18.5	16	16	100.0
18.6—19.5	10	10	100.0

of equal magnitude. As the stock of mature ova is sharply differentiated from the general egg stock it can be inferred that the spawning of this species is restric-

ted to a short and definite period and that the individual fish spawns only once during each spawning season. It is therefore likely that the stock of early maturing eggs represented by the mode y, is the one that gets ready for spawning in the subsequent spawning season. The males examined during the spawning periods were also in mature or spent condition. This was roughly determined by microscopic examination and by size and colour of the fresh testes. The smallest male in a mature condition measured 13.2 cms. in standard length and the largest male in mature or spent state had a standard length of 15.8 cms. About 40% of the total fish examined happened to be males.

The occurrence of large number of fish along the coast only during the spawning periods, indicates that the fish invades inshore waters for the breeding purposes.

In Bombay waters *T. purava* and *T. hamiltonii* are the only predominant species of Thrissocles. The spawning habits of *T. hamiltonii* are similar to those of *T. purava* as can be judged with reference to the work of Palekar and Karandikar (1952). Both these species spawn twice in one year and further in both cases there is a short spawning duration, each individual spawning only once during the season. However, Mookerjee and Mookerji (1950) mention that the breeding season of *Engraulis* (Thrissocles) *hamiltonii* from Bengal, begins from January and prolongs upto the end of July. Similarly *Thrissocles mystax* from Calicut has a prolonged spawning season extending over a period of 8 months from September to May of the following year (Venkataraman 1956), whereas Dharmamba (1959) who has worked on the same species from Lowson's Bay, Waltair, mentions that the spawning of *T. mystax* is restricted to a short, definite period from June to August and again from December to February and that each individual spawns only once in a season. However, in *T. dussumieri*, she mentions that the spawning extends over a long period with individuals spawning twice in each season.

Thus it is evident that the *Thrissocles* species in general show periodicity in spawning but that the duration and frequency of spawning vary from species to species and in the same species even from place to place.

Condition Factor :

A study of the *Condition Factor* or *Ponderal Index* of the fish during the period of investigations shows that the values for the months of October-November and again April-May are considerably low, (Fig. 2), thereby further corroborating the observation on the spawning period of the fish.

Fecundity :

For the study of fecundity, five mature gonads were examined. Number of mature eggs in a gramme sample of the ovary was first counted and then by multiplying this number by the weight of the gonad, the total number of mature eggs in the ovaries was arrived at. These computations gave the following values :—

Length of the fish	*Number of eggs*
15.0 cms.	12495
16.0 cms.	13432
16.5 cms.	13552
17.0 cms.	21197
17.3 cms.	23060
Average	16747

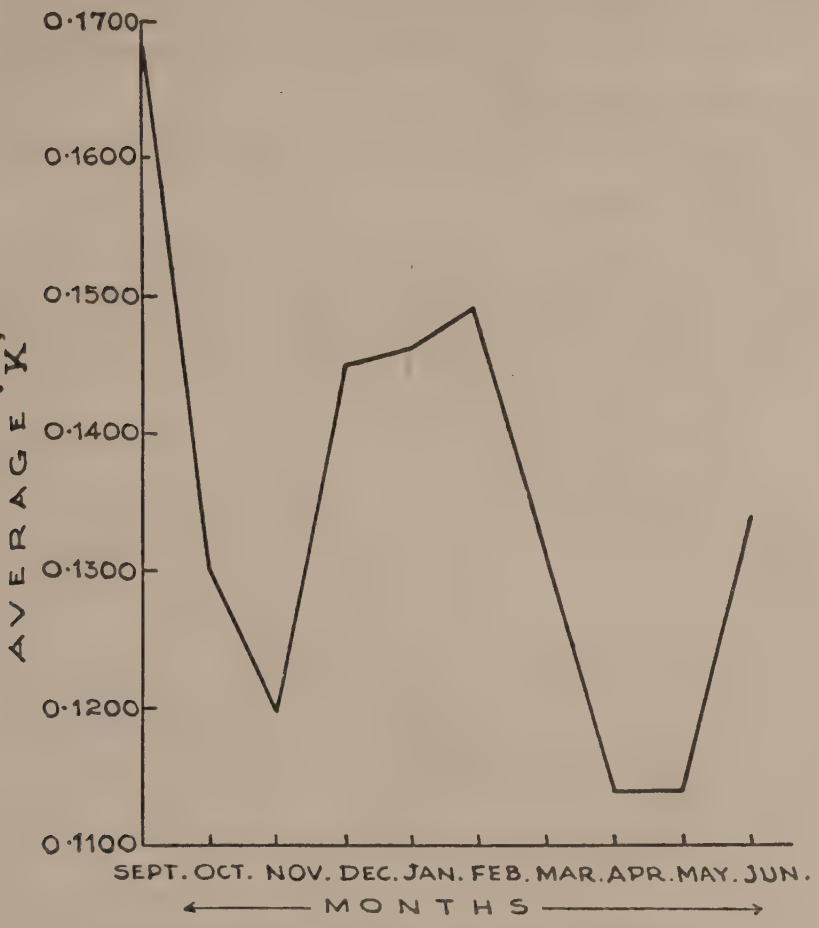


Fig. 2. Monthly Fluctuations in the ' K ' values of *T. hamiltonii*

From this it can be concluded that *T. hamiltonii* contains an average of 16747 mature eggs and that the larger fish may contain as many as 23000 mature eggs.

Size at First Maturity :

For determining the minimum size at maturity females examined in the spawning seasons only, were made use of. The Table B gives the number and percentage of mature and spent fish in each cm. size group. It is seen from this table that the first mature female appears in the group 13.6 to 14.5 cms. where the percentage of mature and spent females is only 6.75. This percentage keeps on gradually increasing till it reaches 100 in the size groups above 17.6 cms. Though a single

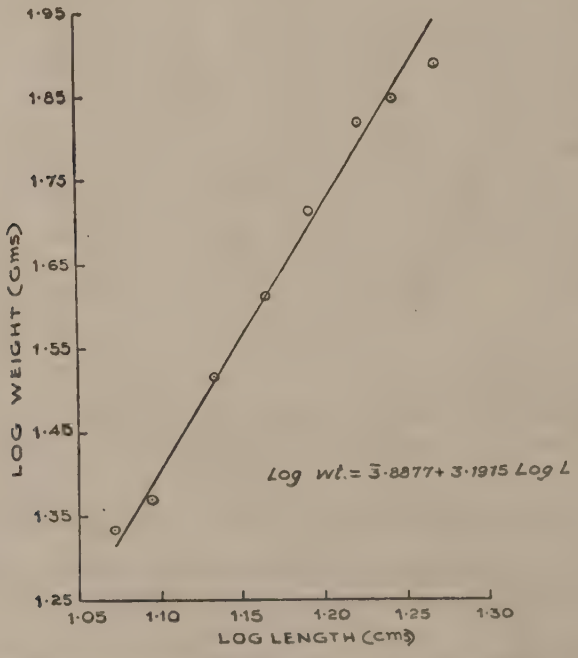
mature fish was recorded at the size of about 14.0 cms., the average size at first maturity can be fixed between 14.6 to 15.5 cms., i.e. at about 15.0 cms. as about 57% of the females in this group are found in either mature or spent condition.

Weight Length Relationship : (Fig. 3 A. & B)

The relationship was calculated from the lengths and weights of 333 specimens of *T. hamiltonii.*

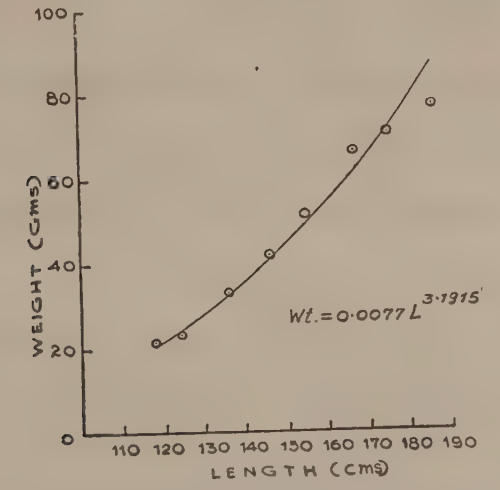
The formula $W=K(L)^n$ or

Log W=Log K+nLog L, where W is the weight, K is a constant, n is the relative growth constant and L is the length, was made use of in determining the relationship. Sexes were pooled when it was found that the relative growth constants for males and females were not significantly different. The equation of the fitted line for the pooled data worked out to be Log $W=\bar{3}.8877 + 3.1915$ Log L.



A-THE REGRESSION OF WEIGHT ON LENGTH, SEXES COMBINED

The curve presented in Fig. 3 B, is derived from the equation $W=0.0077\ L^{3.1915}$. From this it can be concluded that the weight increases as about the cube of length for lengths between 11.0 and 19.0 cms. standard length.



B- THE LENGTH-WEIGHT RELATIONSHIP OF T. hamiltonii

FIG. 3

Summary

In Bombay waters *T. hamiltonii* is found in sizeable quantities during late September to November and again from late March to May. During these periods mature and spent fishes are caught in inshore waters. Post-larval forms of the fish have also been recorded during these periods.

The spawning in this fish appears to be of a short duration though the fish spawns twice in a year. However, the individual fish spawns only once in a season. The minimum size at maturity appears to be about 15.0 cms. The weight length relationship of the fish has been determined and the weight appears to increase as about the cube of length for lengths between 11.0 and 19.0 cms.

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HYDROGRAPHY OF THE LACCADIVES OFFSHORE WATERS[1]

By R. Jayaraman, C. P. Ramamritham, K. V. Sundararamam* and C. P. Aravindakshan Nair

Central Marine Fisheries Research Sub-Station, Ernakulam

Introduction

The importance of the waters around the Laccadives ' with their special ecological conditions and their influence on the adjacent coastal waters of the mainland of India ' has been indicated in an interesting review of the oceanographical investigations in the eastern section of the Arabian Sea by Jones (1959). The Laccadives region is particularly interesting to the oceanographer, because of the presence of the submarine ridge—the Laccadives-Chagos Ridge—which has a great influence on the circulation of the water masses in this part of the Indian Ocean. The ridge contributes, to some extent, to the enrichment of the upper waters of the mid-ocean as has been suggested by Cooper (1957). To the fishery investigator, this region is equally interesting, as it is known to support a rich fishery, particularly of the pelagic type. A detailed hydrographic survey of this region is, therefore, considered necessary as it would help to throw light on several problems of oceanographical and fishery interest.

An account of the distribution of one of the main parameters—dissolved oxygen—has already been presented (Jayaraman *et al.*, 1959) and this has given us some preliminary idea of the hydrographical features of this region. The present paper is to be considered as more or less an extension of the same with more details regarding the distribution of other factors and the pattern of circulation and water movements derived therefrom. The data discussed in this paper refer to the two cruises made in the month of April (1959) which forms a transition between the end of the North-east monsoon and the commencement of the South-west monsoon and is expected to depict more or less stable conditions in this environment.

Collection of Data and Mode of Treatment

Fig. 1 shows the geographical location of the 25 hydrographic stations. Water samples for salinity and dissolved oxygen and temperature data were collected at all the international depths down to 500 metres from these hydrographic stations. All are deep water stations, the depths in each of them exceeding 1,500 metres. The stations which have been occupied have been grouped into six sections covering the entire region and the vertical distributions of the various parameters in all

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*Present address : Oceanography Research Wing of the Central Board of Geophysics, Naval Base, Cochin.

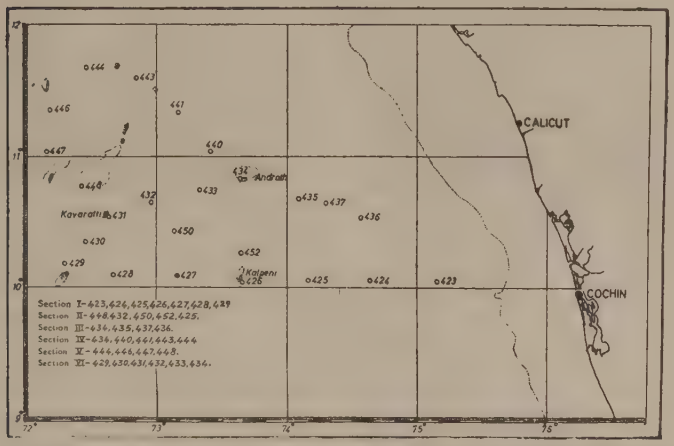


FIG. 1. Chart showing the geographical location of the oceanographic station in the 'Laccadive region'.

these sections have been worked out. Computations of geopotential anamolies have also been made with the available data and with reference to 500 decibar surface, but graphic representations of the same have not been attempted as the number of stations worked is too small to facilitate contouring.

GENERAL CHARACTERISTICS OF THE DISTRIBUTIONS OF PARAMETERS

(*a*) *Temperature*

All the vertical sections (Figs. 2 to 7) have been drawn from the readings of the reversing thermometers after applying the appropriate corrections. The section due west of Cochin (Section I) covers the maximum distance in the area and could be considered as a more or less representative one for purposes of discussion. The positions of the isotherms show that a uniform temperature of about 30°C is maintained in the upper layers. As the whole region has been covered in two cruises, it may be seen that those stations which have been worked in the latter part of the month have slightly higher temperature values. The upper 50 metres are seen to be more or less isothermal. Decrease begins below 50 metres and the thermal discontinuity is observed at about 75-80 metres. The thermocline is very sharp and is seen to have a thickness of nearly 50 metres or even more at a few stations. The deeper layers exhibit more or less uniform distribution of temperature. The isotherms show characteristic 'doming' and 'depressions' which have probably been caused by extensive water movements. This point is, however, discussed in greater detail in a later section of this paper.

(*b*) *Salinity*

The surface values are rather low and there is a steady increase downwards. The salinities are slightly higher in the more northern stations and are in accordance with the distribution of surface salinity in different latitudes as described by

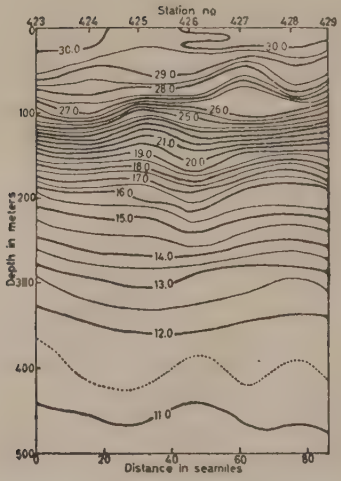


FIG. 2. Vertical Temperature distribution in Section I; In this and the following Sections thick curves represent integral values of Temperature and thin curves represent values at 0,5°C interval.

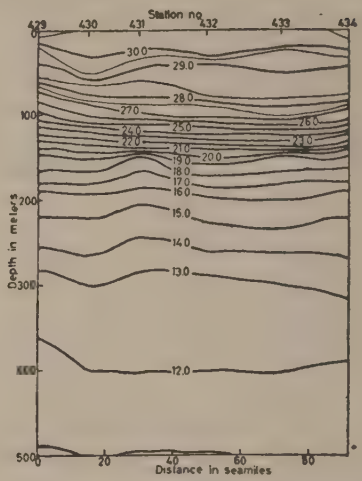


FIG. 3. Vertical Temperature distribution in Section II.

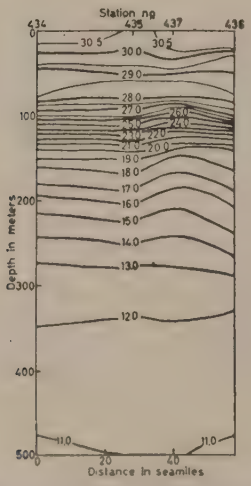


FIG. 4. Vertical Temperature distribution in Section III.

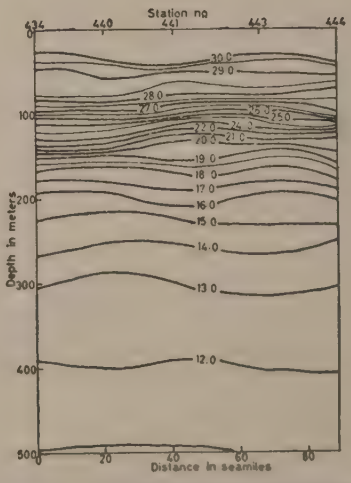


FIG. 5. Vertical Temperature distribution in Section IV.

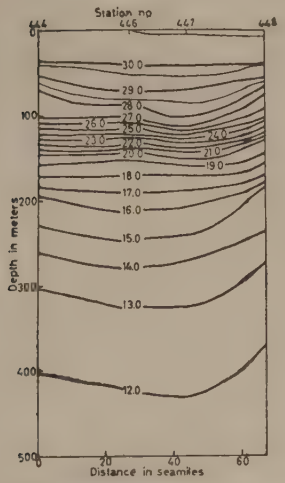


FIG. 6. Vertical Temperature distribution in Section V.

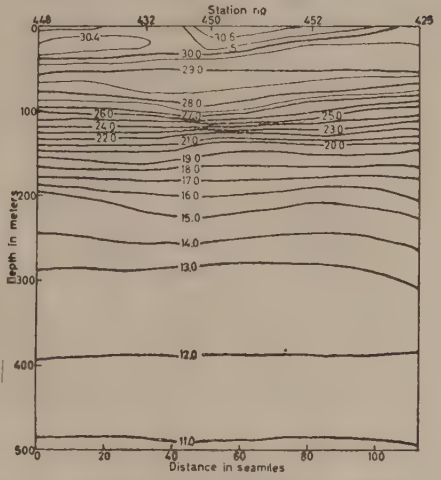


FIG. 7. Vertical Temperature distribution in Section VI.

Sverdrup (1942, p. 124). The most interesting feature about the sub-surface distribution of salinity is the occurrence of salinity maximum at about 100 metres in practically all the stations (see figs. 8 to 13). A tongue of highly saline water with a thickness of about 50 metres is observed to be present and the salinity maximum is seen to occur within this tongue.

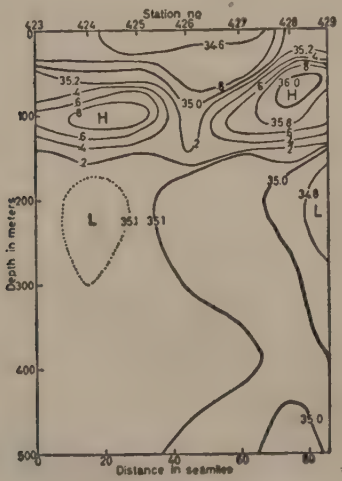


FIG. 8. Vertical distribution of Salinity in Section I.

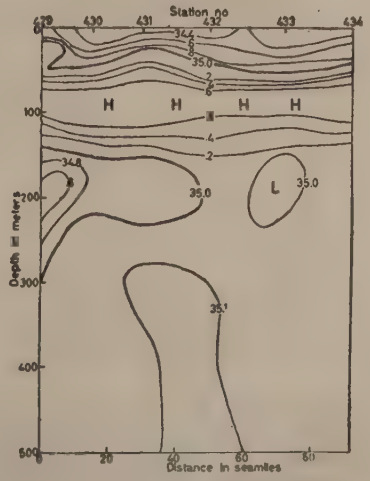


FIG. 9. Vertical distribution of Salinity in Section II.

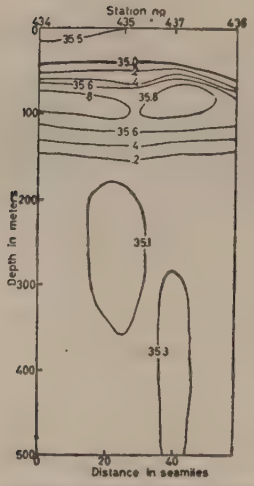


FIG. 10. Vertical distribution of Salinity in Section III

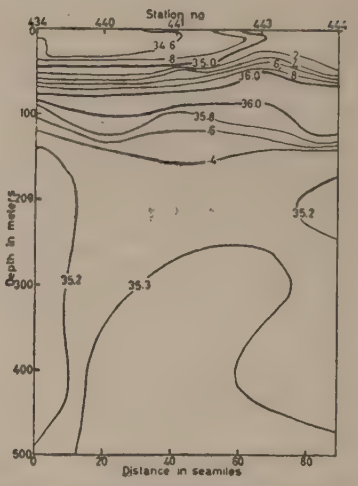


FIG. 11. Vertical distribution of Salinity in Section IV.

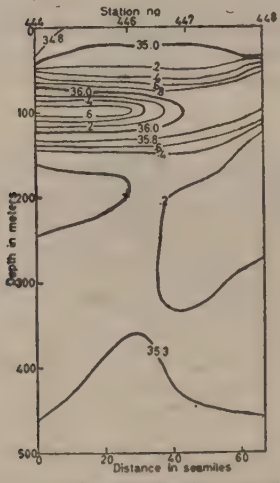


FIG. 12. Vertical distribution of Salinity in Section V.

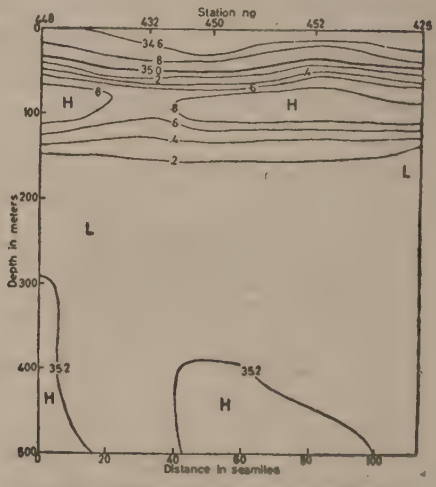


FIG. 13. Vertical distribution of Salinity in Section VI.

In general, in the surface layers, the salinity distribution is more or less uniform as could be seen from the nearly horizontal and unbroken nature of the isohalines. Below the layer of salinity maximum there is a steady decrease of salinity. In these layers the isohalines exhibit a peculiar trend, being nearly vertical in most cases. This is particularly evident in Section I where the 35.10°/$_{oo}$ isohaline extends nearly

in a vertical plane from just below the thermocline and down to 500 metres. Isolated cells of low salinity are also seen to be present.

The occurrence of a salinity maximum at or about 100 metres is considered to be characteristic of the tropical areas of the oceans and several explanations have been offered. In the present instance, one of the possibilities to be considered is the Red Sea influence. Clowes and Deacon (1935), while discussing the distribution of salinity in a section along the east coast of Africa, state that the Red Sea water sinks to a depth of 500 metres at 8°N. latitude as a high saline tongue and is detectable as far as 40°S. latitude at a depth of 1,250 metres. In view of its high density as shown by these authors it does not seem reasonable to postulate that the salinity maximum at 100 metres is caused by the sinking and spreading of the Red Sea water. It may at best be considered as a secondary effect due to a ' random scattering of the disintegrated elements ' of the Red Sea water as has been indicated by Tait (1957) while describing the Gulf of Gibraltar water intrusions in the Faroe-Shetland channel. It is more probable that the salinity maximum as observed by us, is due to the sinking and spreading of the waters of the northern portion of the Arabian Sea, the surface salinity of these waters having been shown to be very high (Jayaraman and Gogate, 1957).

(*c*) *Density*

The vertical distributions of density in the various sections are shown in Figs. 14 to 19. The sigma-t surfaces, like the isotherms, show the characteristic ' domings ' and ' depressions ' and these are much more marked and present practically at all levels.

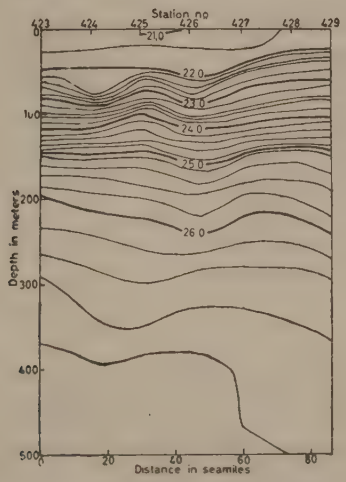


FIG. 14. Vertical distribution of density (Sigma-T) in Section I. In this and the following sections thick curves represent integral values of Sigma-T, and thin curves represent values at 0.2 g./L interval.

An examination of the slopes of the sigma-t surfaces particularly at the subsurface layers gives one the impression that there are water movements of great

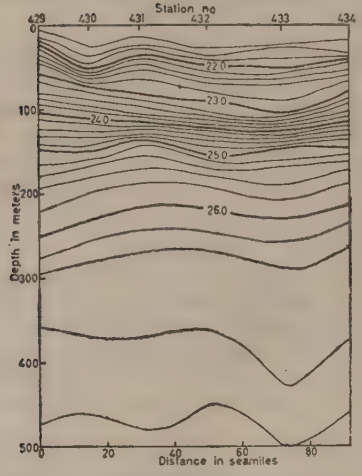


FIG. 15. Vertical distribution of density in Section II.

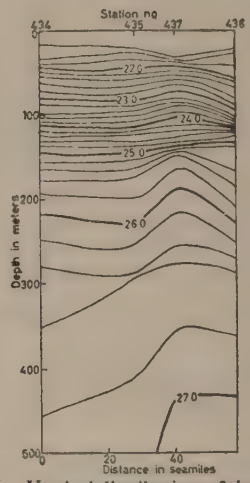


FIG. 16. Vertical distribution of density in Section III.

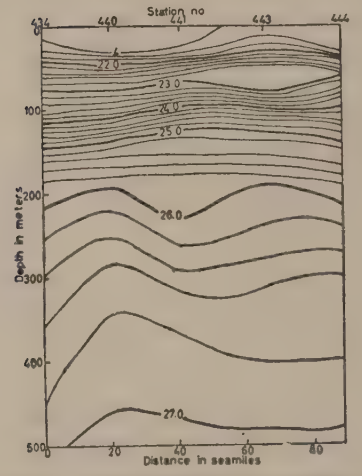


FIG. 17. Vertical distribution of density in Section IV.

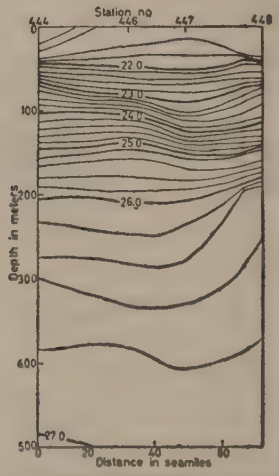


FIG. 18. Vertical distribution of density in Section V.

intensity at the deeper layers. According to Deacon (1937) the slopes of the density surfaces are generally prone to give an exaggerated picture of the strength of the deep currents and the slopes of the layers involve several other factors besides the movement of a particular water mass. In the present instance it was thought desirable to examine in detail the computed geopotential anamolies and to find out

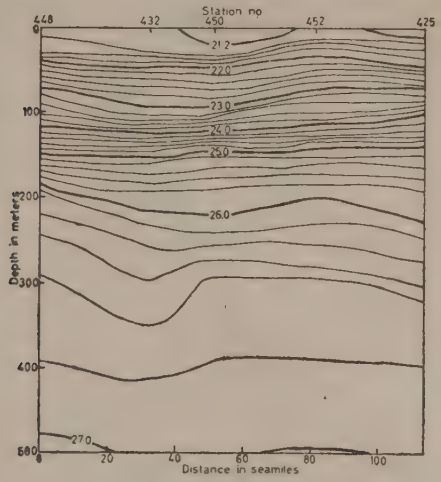


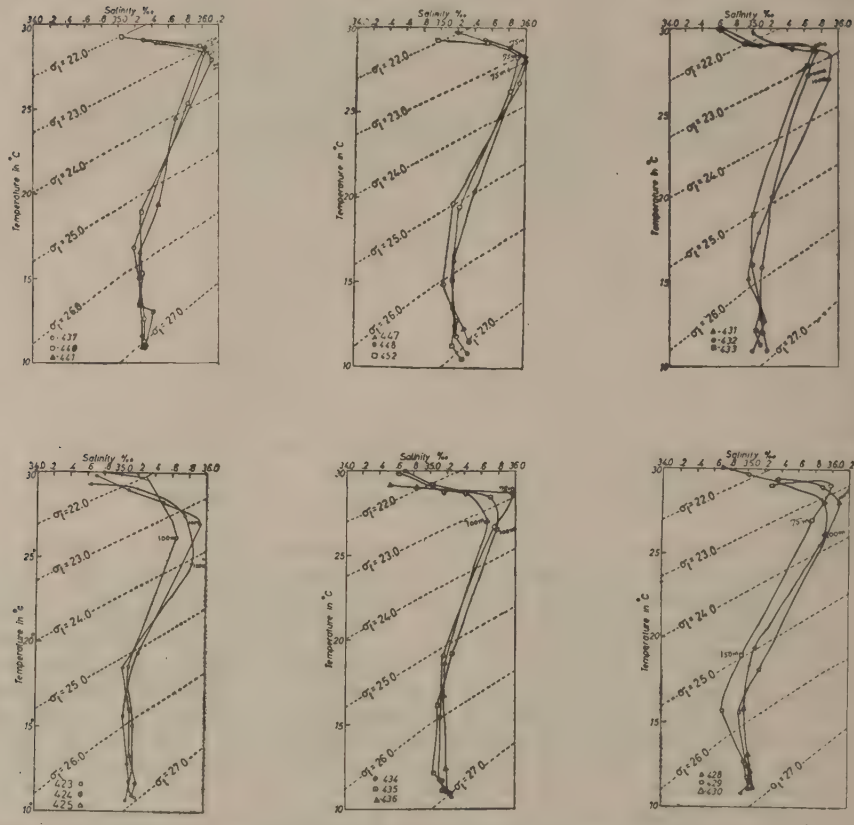
FIG. 19. Vertical distribution of density of Section VI.

whether there are any appreciable deep water movements and if so whether we could get any idea of the intensity of such movements. The inferences drawn from these studies could be briefly stated as follows : The main type of motion that is detectable is the circulatory motion and it is seen to be present around each of the islands. The pattern of circulation is more or less the same. A fairly anticyclonic motion (clockwise circulation) is seen to be present around the islands Kalpeni, Kavarathi and Androth. This type of motion is seen to be present from surface down to the discontinuity layer. At the deeper levels the circulation is completely reversed, the motion being cyclonic in most of the stations. The *Hugh M. Smith* cruises in the Hawaiian offshore waters have also revealed the presence of similar circulatory movements round the islands (McGary, 1955 ; Seckel, 1955). Whatever be the detailed pattern of circulation, it is fairly clear that in the Laccadives region, the waters are kept circulating in the vicinity of the islands most of the time. There does not seem to be any appreciable degree of lateral transport of the water masses at least during this season.

TEMPERATURE-SALINITY RELATIONSHIPS AND INFERENCES REGARDING THE DIFFERENT WATER MASSES IN THIS REGION

The T.-S. diagrams for a few selected stations are given in figs. 20 to 25. In discussing the relationships the surface waters and sub-surface waters down to 30 metres have been omitted as they are very much influenced by local conditions, biological activity etc. The water masses below this level of 30 metres could be classified in the same way as has been done by Sastry (1960) for the waters along the Kerala coast. The three main types as observed by us are:

(1) The water mass down to 75-100 metres is characterized by a rather sharp salinity gradient with a very small temperature range. The sigma-t values range



FIGS. 20—25. Temperature-Salinity relationships of a few selected stations.

between 21.00 and 23.00. Sastry while describing a similar water mass in the Kerala Coastal waters, states that it is this water mass which participates most in the upwelling and sinking phenomena. This probably corresponds to the Arabian Sea upper sub-surface water described by Sastry.

(2) The second one is characterized by a steep temperature gradient with a salinity range hardly exceeding 0.8°/$_{oo}$ The sigma-t values lie between 23.00 and 25.00. This seems to be much better defined than the first one. This could be termed as the Arabian Sea Lower Sub-surface water.

(3) The water mass below 200 metres is characterized by having small temperature and salinity gradients. In some stations, it almost appears like isohaline water. From an examination of its temperature and salinity characterist as well as its density range, this water mass could be identified as the Indian Ocean Equatorial water (Sverdrup, 1942).

Remarks Concerning the Circulation of Water Masses and the Productivity of the Laccadives Region

The geostrophic pattern of circulation derived in the preceding paragraphs studied in conjunction with the vertical distribution of dissolved oxygen indicated in the previous paper (Jayaraman *et al.*, 1959) brings out certain interesting conclusions regarding the water movements and the productivity of the Laccadives region. In this connection it would be worth while to refer to the interesting paper by Richards (1957), wherein it has been stated that the oxygen-minimum layer especially in the tropical waters is closely related to the organic productivity of the waters and the great differences in the depths at which the oxygen-minima are found are attributed to the differences in the productivity. It is observed that in these waters the oxygen-minimum layer is several metres thick and the upper level of this layer is seen to be present at 150 metres. (It is generally found in the open parts of the ocean at about 300 metres). Both these observations more or less conclusively point to a rather high level of productivity of the Laccadives waters. It may be seen that the circulatory water movements help to maintain the highly productive waters in the vicinity of the islands for a considerable length of time. It is also indicated as a possibility that this circulatory motion helps to keep the fish eggs and larvae in the highly productive waters of this region, thereby providing them a favourable environment. It may thus be stated that one of the most significant relationships between the animate environment and the inanimate (physical) environment is seen to have been fairly well established in the waters of the Laccadives region.

Summary

An account of the main hydrographical features of the Laccadives offshore waters is presented. The results relate to the period of the year when stable conditions are expected to exist in the environment. The temperature distributions indicate the presence of a more or less isothermal water down to 50 metres. The discontinuity layer is observed to be between 75 and 150 metres. A salinity maximum is seen to occur within a tongue of high saline water at about 100 metres. From the nature of the density surfaces and the computed geopotential anomalies it is inferred that there are circulatory water movements around the islands at practically all levels down to 500 metres ; the motion is anticyclonic in the upper 100 metres and reverse of that below that level. The importance of such circulatory movements in keeping the highly productive waters around the islands is indicated.

Acknowledgements

The authors' thanks are due to Dr. S. Jones, Chief Research Officer and Dr. Raghu Prasad, Senior Research Officer (Marine Biology), Central Marine Fisheries Research Station and to Mr. Østvedt, Research Adviser, Indo-Norwegian Foundation, Ernakulam, who have participated in the cruises and given full encouragement and help in carrying out these investigations. The valuable assistance given to us by the officers and crew of *R.V. Kalava* is also gratefully acknowledged.

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THE MORPHOLOGY AND LIFE HISTORY OF *ECHINOCHASMUS BAGULAI* VERMA, 1935 (TREMATODA : ECHINOSTOMATIDAE) WITH ECOLOGICAL OBSERVATIONS ON ITS LARVAL FORMS*

By K. Ramalingam**

Central Marine Fisheries Research Station, Mandapam Camp

Introduction

Preliminary and fairly detailed examination of the predominant molluscs of the mudflat at Pamban for metacercariae (cysts) and cercariae revealed the occurrence of an echinostome cercaria in *Natica marochiensis* Gmelin, which bore striking resemblances, chiefly in the number, arrangement of the collar spines and in the nature of the excretory vesicle to the metacercarial cysts which I have come across in the bivalve *Katelysia opima* Gmelin. This casual discovery led to the study of its life history by undertaking feeding experiments. A similar method was employed by Beaver (1941) and Yamaguti (1951) in tracing the life histories of *Echinochasmus donaldsoni* and *Echinochasmus japonicus* respectively.

The partially and completely known life history studies on the different species of the genus *Echinochasmus* Dietz [Beaver (1941), Ciurea (1920, 1933), Johnston & Simpson (1944), Miki (1925), Muto (1921), Ujiie (1936) and Yamaguti (1933, 1951)] reveal that the larval stages of these trematodes occur in freshwater hosts except that described by Ciurea (1933). He recorded metacercarial cysts of *E. liliputanus* from the gills of a marine fish and on feeding these cysts to dog he obtained the adult forms. Thus our knowledge of the life history of the members of the genus having their larval stages occurring in marine hosts is very meagre. It is with the object of supplementing further data on these marine echinostome larvae as well as their life history that this work is attempted.

Even though the work on freshwater forms of this genus has been more extensive than on the marine forms, it is only with reference to one species, *E. rugosus* that the miracidial stage has been successfully recorded (Yamaguti, 1933). This, incidentally, is also the only available record of the miracidium of this genus.

Material and methods

The snail *Natica marochiensis* and the bivalve *Katelysia opima* were used as the source of the echinostome cercaria and metacercaria (cysts) respectively. Collections of these snails and bivalves were made from the tidal mudflat at Pamban twice during a month for a period of two years namely 1954 and 1955. The above hosts

* Formed part of thesis approved for the degree of Doctor of Philosophy of the University of Madras.

** Present address : Zoological Research Laboratory, University of Madras, Chepauk, Madras-5. S. India.

were brought to the laboratory and were reared in the laboratory to make observations on the emergence and behaviour of the cercariae. Snails measuring on an average of 15 mm. and above were only used in the studies for determining the infection. Smaller ones were not studied as it was difficult to establish beyond doubt the cercarial infection in these even though they might have been infected. The method adopted by Stunkard (1943) was followed in determining the percentage of infection.

A total of 3074 specimens of *Natica marochiensis* and a total of 611 specimens of *Katelysia opima* were examined in this study. For the examination of the snail (*Natica*) and the bivalve (*Katelysia*) populations the following procedure was adopted. The general area in which *Natica* occurred on the mudflat was divided into 15 equal segments (30 yards square) and a random sampling from these segments was made. The average count per month per unit area was made and from this the total population estimate was obtained and is presented in Table 1 (vide p. 43). This procedure was not adopted in the case of the bivalve *Katelysia* because of its relative scarcity and so the entire area was surveyed every time when collection was made.

The infected bivalves were fed to the following birds : the gull-billed tern (*Gelochelidon nilotica*), the black-headed gull (*Larus ridibundus*), the curlew (*Numenius arquata*), the common or fan-tail snipe (*Capella gallinago*), the little egret (*Egretta garzetta*) and the pond heron (*Ardeola grayi*) which were observed to frequent the above mudflat. Besides these birds, the infected bivalves were fed to the domestic duck (*Anser domesticus*) also. Side by side with the feeding experiments, the birds of the above species, used as controls, were also examined. A thorough examination of the faeces of the artifically infected birds was made for the parasites and its eggs. As I had to depend on the bird catchers for the supply of birds, I had to confine myself to the examination of the above hosts for determining the definitive natural hosts.

Adult worms, obtained from the autopsied experimental birds, were studied alive and they were fixed in formalin (7%) as well as in alcoholic Bouin's fluid. They were stained in alcoholic borax carmine, alum carmine and Ehrlich's haematoxylin and blued in alcoholic-ammonia mixture.

The details of the excretory system were made out from a number of immature cercariae got by teasing out the digestive gland of infected *Natica marochiensis*. The cercariae were studied alive. Ceracriae used for making mounts were fixed with hot 7% formalin under cover slip pressure with least contraction and undue expansion. They were stained with the above stains.

Description of the area studied

The mudflat at Pamban is nearly a mile long with a maximum width of five to six furlongs. The longer axis of the flat is in a North-westerly direction and the sea is on the western side. There is no other mudflat area present in the near vicinity. Pamban channel (four fathoms deep) runs in the North-south direction about 20 feet away from the low tide mark and is parallel to the mudflat. Since this deep channel separates the mudflat from the nearby islands there is no possibility of mingling of populations between the mudflat and the islands nearby. Thus the first and the second intermediate hosts occur along with the other molluscan fauna as an isolated population.

Morphological description of :

Cercaria (Figs. 1 and 2.)

Echinostome cercariae described from marine snails are very few as compared with those described from freshwater hosts, and chiefly relate to the works of Lebour (1911), Martin (1955) and Cable (1956). There is no record of an echinostome cercaria from the snail *Natica marochiensis* and this is the first record of a marine cercaria from India.

It was observed that cercariae emerged from *Natica* in greater numbers during day time than during nights. A single *Natica* kept under observation liberated during day time on three consecutive days 295, 193 and 147 cercariae and the numbers during the corresponding nights were 10, 7 and 4 thus exhibiting a diurnal periodicity. Diurnal periodicity was also observed by Cort (1922) and Rees (1948). The cercariae held in a finger bowl were found to accumulate on the side facing the source of light thus exhibiting photo-positive orientation and a similar observation was made by Rees (1948) in *C. purpurae*.

Live cercariae ranged from 0.91 mm. to 1.10 mm. in length and in contracted condition it ranged from 0.25 mm. to 0.28 mm. In moderately extended, fixed specimens length ranges from 0.58 mm. to 0.88 mm. and the width is from 0.16 mm. to 0.26 mm. Its shape is elongately oval. Tail is approximately equal to one-third the length of the body in normally extended specimens. At the posterior extremity of the tail is present a pair of glands which open into the vesicle. Acetabulum is situated in the posterior region of the middle third of the body and its diameter ranges from 82μ to 119μ. The future collar region is seen as a distinct thickening but is not well developed. The collar spines are seen as small refractile bodies when stained with vital stain methylene blue. Their arrangement (Fig. 2) is exactly similar to the type met with in the metacercaria (described below) and the adult. They are interrupted dorsally, with 12 spines on each half of the collar and the dorsal innermost overlaps the oral sucker. The inner row of spines measure 7μ in length and the outer row 9μ in length except the 8th and 10th spines on either corner of the collar which measure 11μ in length.

Four pairs of penetration glands are present on either side of the median line embracing the anterior border of the acetabulum and they open by four pairs of ducts at the anterior end. Unicellular glands are abundant throughout the body. Four pairs of glands are present along the posterior wall of the oral sucker and they open by fine ducts at the anterior end.

Oral sucker diameter is from 45μ to 62μ. Pre-pharynx is short and measure from 22μ to 49μ in length and 27μ to 38μ in width. Oesophagus is from 0.18 mm. to 0.27 mm. in length and it bifurcates in front of the acetabulum and the caeca extend to the posterior end of the body where they terminate blindly.

The excretory system.—The excretory vesicle is chambered and the posterior chamber is larger than the anterior. The vesicle opens to the outside posteriorly on the dorsal surface of the body at the point of attachment of the tail. From the anterior chamber at its antero-lateral border the two main collecting trunks arise. The trunks upto the posterior level of the acetabulum are broad and full of excretory granules. From about the middle of the acetabulum they are narrow and proceed forward to the level of the pharynx, taking approximately a parallel course all along.

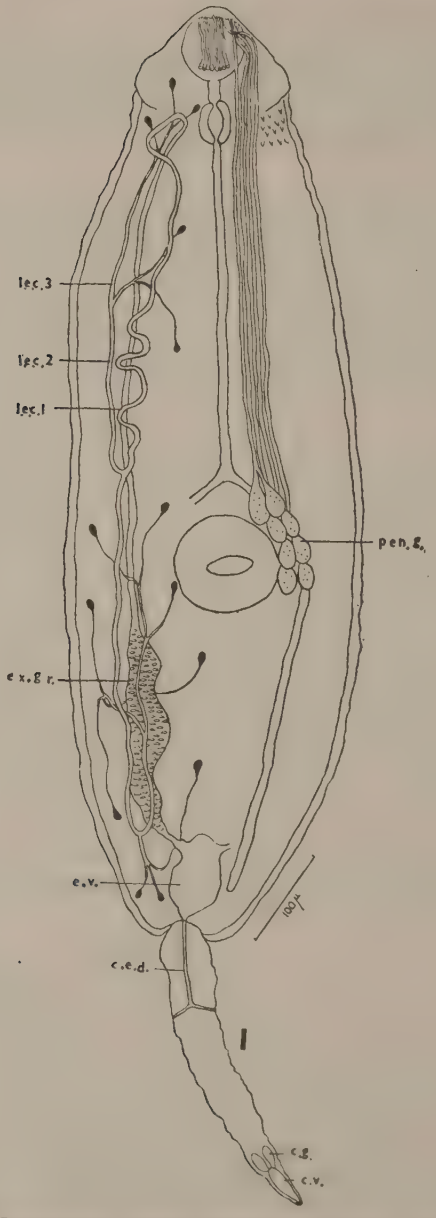


FIG. 1. Cercaria of *Echinochasmus bagulai* showing the excretory system, glands and their ducts.

The two ducts (l.e.c.1) converge a little posterior to the pharynx. The main canals beyond this level are narrow. They make a triangular loop (characteristic of echinostome cercariae) and pass backward on to the inner side of the main ascending canal and bifurcate in front of the acetabulum into the anterior and posterior secondary collecting tubules (l.e.c.2). The anterior collecting tubule divides into two branches the tertiary tubules (l.e.c.3) whereas the posterior collecting tubule divides into three branches. The flame cell arrangement in this cercaria can be represented by the following formula 2 $[(3+2)+(3+3+3)]=28$. A longitudinal canal starts from the posterior part of the vesicle and extends into the tail to one-fourth of its length and at that level it bifurcates into two lateral ducts which reach the sides of the tail.

Redia (Figs. 3 and 4.)

Heavily infected specimens of *Natica marochiensis* harbour rediae in all stages of development.

Well developed rediae measure from 0.90 mm. to 1.25 mm. in length and from 0.26 mm. to 0.29 mm. in breadth. The collar in younger specimens is conspicuous. It encircles the body in the region immediately posterior to the pharynx. Birth pore is dorsal and is on the left side just posterior to the collar, 0.15 mm. to 0.18 mm. from the anterior end. At about the middle are seen a pair of ventro-lateral appendages, the procruscula. In younger specimens they are quite pronounced long and vermiform. But in older specimens they appear as gentle curves.

Digestive system.—Mouth leads to a small vestibule just in front of the pharynx. A little posterior to the mouth opening and on either side is seen a small mass of gland cells which open into the vestibule. The pharynx is well developed and its diameter is 44μ to 56μ. The pharynx leads into a sacculate gut extending as far as the level of the appendages in younger specimens. In older forms having cercariae the sacculate gut is pushed to one side.

Cercariae in various stages of development occur in older rediae, numbering from four to eight and besides a few cercarial embryos also occur. They lie freely in the body cavity of the redia and move back and forth with the movement of the redia. The body of the fully developed cercaria near the birth pore region measures from 0.48 mm. to 0.52 mm. in length.

Metacercaria (Figs. 5 and 6.)

The earliest record of an echinostome metacercaria in a marine bivalve (*Scorbicularia tenuis*) is that of Villot (1879). Subsequently, various marine bivalves are described as harbouring echinostome cysts [Lebour (1908) and Stunkard (1938)]. This is the first record of echinostome cysts from *Katelysia opima* (and the first to be described from India though two other species of *Katelysia* (*Tapes*) *pullastra* and *K.* (*Tapes*) *decussatus* are known to harbour echinostome cysts [Lebour (1908) and Palombi (1934) respectively].

A maximum of 395 cysts were once recorded from a single infected bivalve. These cysts are found encysted in the foot usually at the junction of the posterior half of the body with the foot, though occasionally a few are found encysted in the gill-lamellae and the mantle.

The metacercarial cyst is spherical, measuring from 0.32 mm. to 0.39 mm. in diameter and is double walled. The outer wall is thick and tough and is formed of the connective tissue of the host. Its thickness ranges from 25μ to 32μ. The inner wall is thin and transparent. The metacercaria occupies the entire space within the cyst.

The metacercariae got from the teased out cysts measure from 0.52 mm. to 0.58 mm. in length and 0.23 mm. to 0.29 mm. in width. The collar is 130μ to 142μ in width and the collar spines are more prominent. The inner row of spines measure 10μ in length ; the spines of the outer row measure 12μ in length except the 8th and 10th which measure 14μ in length. Acetabulum measures from 97μ to 102μ in length and 112μ to 126μ in width.

Oral sucker is half the size of the acetabulum and measures from 42μ to 51μ in width and its length is approximately the same as the width. Pharynx measures from 25μ in length by 43μ to 52μ in width. Oesophagus measures from 47μ to 55μ in length and bifurcates immediately anterior to the acetabulum. The cacea extend to the posterior end of the body.

The excretory vesicle is chambered and anteriorly it bifurcates into the two main collecting trunks.

The primordium of the anterior testis measures from 12μ to 16μ in length and 18μ to 22μ in width, while the posterior one measures from 19μ to 23μ in length and 18μ to 21μ in width. The primordium of the ovary is situated in the posterior region of the middle third of the body and its size is from 14μ to 17μ long and 27μ to 32μ broad. The cirrus primordium is seen as a small mass of deeply stained cells behind the intestinal bifurcation. The post-testicular space is approximately one-fifth the total length.

Adult (Figs. 7 to 9.)

Regular examination of the different birds mentioned earlier (vide p. 36) during the different seasons of the year when they were available did not, however, show the presence of adult echinostome in their alimentary canal except on one occasion when nine trematodes belonging to a different genus were found in the intestine of the little egret (*Egretta garzetta*). The experiments of artifically infecting the birds by feeding them with the infected bivalves showed that though the metacercariae excysted in all the different hosts, they reached their adult stage only in the following birds, viz., the black-headed gull, the curlew, the little egret and pond heron. The worms reached their adult stage at different interval of periods. viz., 6 days after feeding in the case of pond heron, 8 days after feeding in the little egret, 10 days after feeding in the gull and 12 days after feeding in the curlew. The development of cysts to the adult worm in such a relatively short period (6 days after feeding) was observed in *E. donaldsoni* by Beaver (1941) and in the case of *E. japonicus* it was even earlier, the cysts developing to the adult in 94 hours after feeding (Yamaguti, 1951). They did not excyst in the domestic duck.

The worms obtained by the indirect method (i.e., from the experimental birds) showed characters that are similar to those present in *Echinochasmus bagulai* described by Verma (1935) from *Ardeola grayi* except in certain characters. These

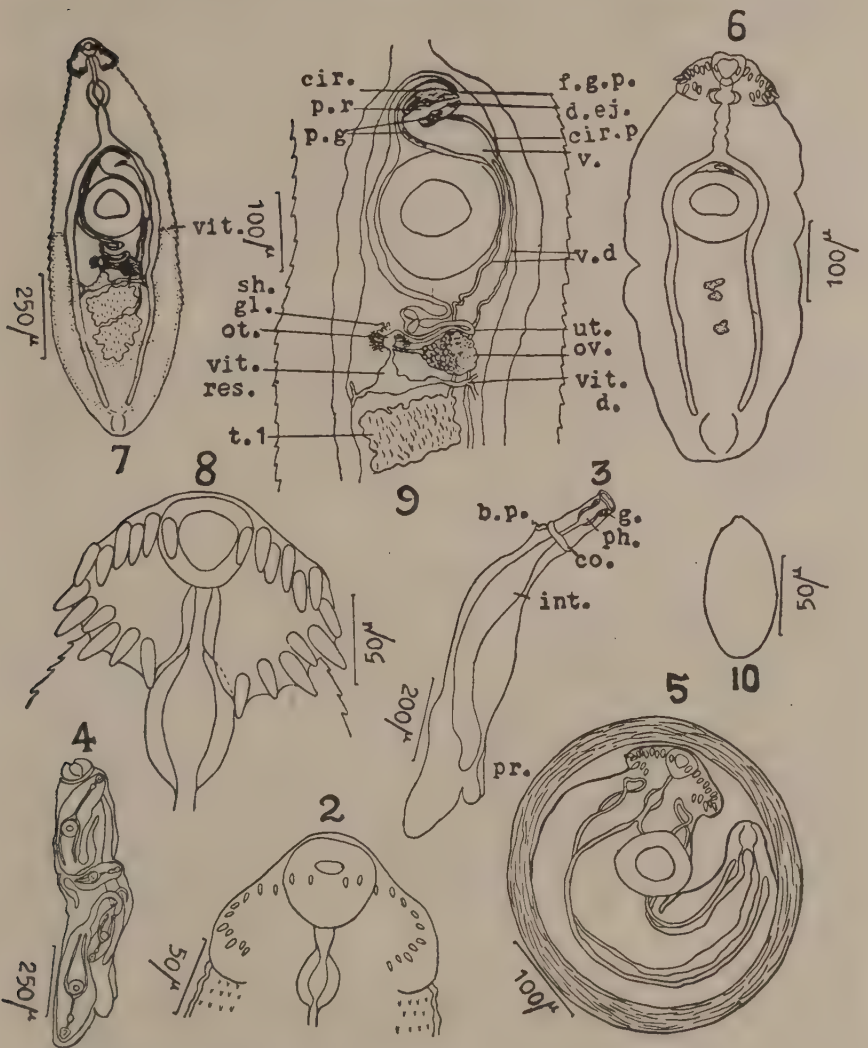


FIG. 2. Arrangement of the collar spines in the cercaria.
FIG. 3. Younger redia of *Echinochasmus bagulai*.
FIG. 4. Older redia of *Echinochasmus bagulai*.
FIG. 5. Metacercarial cyst of *Echinochasmus bagulai*.
FIG. 6. Metacercaria of *Echinochasmus bagulai* teased out from the cyst.
FIG. 7. Adult *Echinochasmus bagulai*.
FIG. 8. Collar of *Echinochasmus bagulai* showing the arrangement of the spines.
FIG. 9. Gonads and their ducts of *Echinochasmus bagulai*.
FIG. 10. Egg of *Echinochasmus bagulai*.

worms are designated as *E. bagulai* and a brief description of it is presented here for a comparison.

Length of the worm 0.8 mm. to 1.46 mm.; maximum width 0.34 mm. to 0.48 mm. Oral sucker 45μ to 64μ in diameter. Collar reniform, 0.10 mm. to 0.15 mm. broad with 24 spines interrupted dorsally and arranged in two rows, alternating with one another; spines of the inner row 21μ to 27μ long; outer row of spines excepting the corner spines (8 and 10) on either side 34μ to 30μ long and the corner spines 33μ long. Pre-pharynx 21μ to 42μ long. Pharynx 61μ to 82μ long and 47μ to 82 μ broad. Oesophagus one to two times the length of the pharynx. Acetabulum 0.16 mm. to 0.21 mm. in diameter. Testes median close behind one another and occupy nearly from one-third to two-fifth of the post-acetabular space ; anterior testis 61μ to 121μ long and 134μ to 206μ broad and posterior testis 76μ to 182μ long and 107μ to 200μ broad. Cirrus sac elongate cylindrical, 115μ to 190μ long and 35μ to 55μ broad. It extends from behind the intestinal bifurcation to a maximum of one-seventh of the acetabular length behind the anterior margin of the acetabulum. As the cirrus sac extends around the acetabulum it partly overlaps the latter on the dorsal side. The enclosed vesicula seminalis is an elongate tube, greatly folded upon itself. Its limiting wall is continuous with the wall of the cirrus sac posteriorly at which point the vas deferns enters. In the retracted condition it forms an S-shaped bend. Anteriorly it is continuous through the pars prostatica into the ductus ejaculatorius which opens at the extremity of the cirrus.

Ovary oval in shape 45μ to 75μ broad and 36μ to 61μ long; situated to the right of the median line just behind the beginning of the posterior half of the body. Oviduct arises at the inner narrow side of the ovary and passes to the ootype and the latter is surrounded by shell glands. Vitelline follicles extend from behind the acetabulum and they are lateral to the caeca upto the hinder border of the posterior testis beyond which they are both extracaecal and intracaecal, meeting in the median line. Transverse vitelline ducts are present in between the ovary and the anterior testis. They proceed inwards and at the place of joining they form a large reservoir. It is situated slightly to the left of the median line. By a short common vitelline duct it discharges its contents into the ootype. The uterus is thrown into three coils between the ventral sucker and the ootype. It proceeds forwards to the metraterm which lies dorsal to the acetabulum and is on the left side of the worm. Its anterior end is somewhat ventral to the terminal portion of the cirrus sac and terminates at the shallow genital atrium. A maximum of 16 eggs were present in one of the specimens examined. The eggs measure from 61μ to 90μ in length and 35μ to 38μ in width.

Egg (Fig. 10)

The egg shell is golden yellow in colour. It is oval in shape. The opercular opening measures 18μ in width.

The faeces of the experimental birds did not contain eggs of *E. bagulai* in them even though they harboured mature worms in their intestine. Hence eggs from the uterus of mature *E. bagulai* were taken every time and reared in the laboratory by placing them along with the first intermediate host (the snail *Natica*) and also without them in order to follow the development to the miracidia. In both cases the eggs lived only for a maximum of three days after which period they disintegrated and died. As the supply of eggs was thus limited, the rearing experiment could not be

successfully completed to the miracidial stage. So far there is no description of the miracidial phase of a member of the genus *Echinochasmus* except that of *E. rugosus* by Yamaguti (1933) who obtained it by indirect methods and it seems therefore that the miracidium is the most elusive stage of the genus *Echinochasmus*.

Host-parasite relationship

Observations on the seasonal trematode infection in freshwater snails have been reported by Sewell (1922), Rees (1932), Cort *et al.* (1941) ; on estuarine snail by Rothschild (1941) ; on marine snails by Miller and Northup (1926) and Martin (1955). The latter two authors have not extended their investigations to the second intermediate host. It is with the object of supplementing their data on the seasonal infection in the marine hosts by the cercaria of *Echinochasmus bagulai* that the following observations are presented.

Among the snails and the bivalves of the mudflat at Pamban examined for infection, it was observed that the snail *Natica marochiensis* and the bivalve *Katelysia opima* harboured the cercaria and metacercaria respectively of the echinostome trematode *E. bagulai*.

The percentage of cercarial infection varied during the different months of the year and they are presented in the Table below.

TABLE I

Percentage of cercarial infection of *Natica* for the years 1954 and 1955

Months	1954			1955		
	Total No. examined per unit area	No. infected	%	Total No. examined per unit area	No. infected	%
January ..	120	15	12	130	14	11
February ..	220	33	15	270	46	17
March ..	275	28	10	300	36	12
April ..	85	8	9	95	8	8
May ..	82	12	14	76	12	16
June ..	74	9	12	84	9	11
July ..	88	7	8	94	7	7
August ..	83	6	7	82	5	6
September ..	90	5	6	96	6	6
October ..	130	8	6	116	6	5
November ..	120	6	5	105	4	4
December ..	144	3	2	115	4	3

In Graph A the percentage of cercarial infection as well as the estimated population of *Natica* are plotted against the different months of the years 1954 and 1955.

Similarly the percentage of infection in *Katelysia* is presented in the Table below.

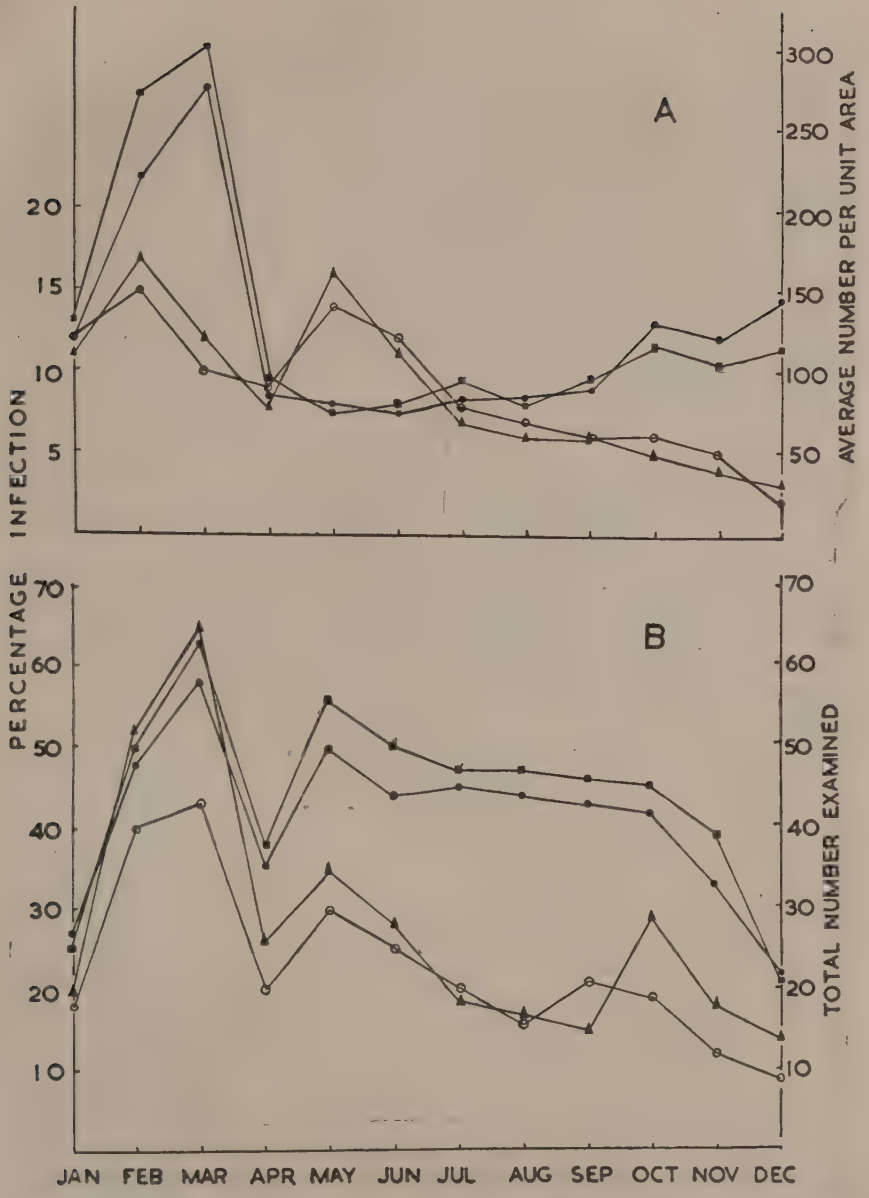
TABLE II

Percentage of metacercarial infection of *Katelysia* for the years 1954 and 1955

Months	1954			1955		
	Total No. of bivalves examined	No. of bivalves infected	%	Total No. of bivalves examined	No. of bivalves infected	%
January ..	18	5	27	20	5	25
February ..	40	19	48	52	26	50
March ..	43	25	58	65	41	63
April ..	20	7	35	26	9	38
May ..	30	15	50	35	19	56
June ..	25	11	44	28	14	50
July ..	20	9	45	19	9	47
August ..	16	7	44	17	7	47
September ..	21	9	43	15	7	46
October ..	19	8	42	29	13	45
November ..	12	4	33	18	7	39
December ..	9	2	22	14	3	21

In Graph B the percentage of metacercarial infection as well as the total population of this host, plotted against the different months of the years 1954 and 1955, are shown.

The population trend in *Natica* in the years 1954 and 1955 is more or less the same. The population is maximum in the months February and March in both the years after which there is a fall. The same is true also of the percentage of infection for the two-year period which reaches to a maximum first in February and again in May. These peaks are well understood when related to the life history of the parasite studied here. The first peak of the cercarial population occurs in February. Naturally, therefore, the miracidial phase must have occupied the period immediately preceding the first cercarial peak, which incidentally coincides with the occurrence of predominantly juvenile forms of *Natica* in the mudflat. That the juvenile stage is the most susceptible period in the life of the host for miracidial infection has been established by Krull (1931, 1934), Ameel (1934) and Cort *et al.* (1941). Therefore it is presumed that the miracidia of this species grow in with the juvenile *Natica* and become cercaria in the host by February. The miracidia themselves must have been developed from the eggs liberated along with the faecal matter of some final host harbouring the mature parasite. Life history studies on the different species of the genus *Echinochasmus* reveal that the final host to be vertebrates and in this case it seems to be birds—an inference drawn from the feeding experiments conducted. The appearance almost simultaneously at this period, of the birds which have been found experimentally susceptible to infection by cysts of this parasite affords more or less an ideal coincidence and condition for the completion of the missing portions of the life cycle of the parasite, namely, the egg and the miracidial phase. The birds referred to appear in the mudflat in November and stay on to the end of April



A. Host-parasite relationship of *Natica marochiensis* and cercaria of *Echinochasmus bagulai* for the years 1954 and 1955.

Percentage infection of *Natica* for the year 1954.
Percentage infection of *Natica* for the year 1955.
Population data of *Natica* for the year 1954.
Population data of *Natica* for the year 1955.

B. Host-parasite relationship of *Katelysia opima* and metacercaria of *Echinochasmus bagula* for the years 1954 and 1955.

Percentage infection of *Katelysia* for the year 1954.
Percentage infection of *Katelysia* for the year 1955.
Population data of *Katelysia* for the year 1954.
Population data of *Katelysia* for the year 1955.

the following year. It is again tentatively suggested here on the basis of circumstantial evidence that the birds are final hosts for this parasite. Such an evidence of the final host appearing at a time immediately preceding the cercarial peak was also given by Rankin (1939) and Rothschild (1941). Apart from this consideration it is very clearly shown in the Figure that there is almost an identical rise and fall in the host and parasite populations throughout the two-year period.

Bimodality.—In Graph A two cercarial peaks are seen one in February and the other in May. As was demonstrated in the experiments conducted in the laboratory, the cercaria need only about nine days to complete their larval development to the cyst stage as well as to the egg producing adult. From the frequency with which the eggs of the adult worms are cast off along with the faeces of the bird-hosts, one would expect that the casting of eggs would continue at the same rate at which they are liberated by the parasite itself. But from the Graph A which shows two distinct cercarial peaks, it can be inferred that the rate of production of eggs might not be regular as is reflected in the bimodal cercarial peaks which are produced at almost equal intervals. It can further be inferred that the development of the egg into the cercaria would normally take about two months approximately (which is not abnormal as can be verified from the works of Beaver, 1937). The possible interplay of various unknown factors causing the cercarial peaks is, however, not precluded from this observation.

In Graph B it is seen that the second intermediate host which becomes infected with the metacercarial cysts, also displays more or less the same host-parasite relationship that was seen for the first intermediate host and the cercaria.

The following chart summarizes the relationship of the parasite to its hosts, on the basis of the experimental and field observations traced in this work.

Effects of parasitism

The observations presented under this title are restricted to the effects of the parasitism on the first and the second intermediate hosts only. The lethal effect of the larval trematodes more especially on their snail hosts have been recognized by Faust (1917), Rees (1936), Rothschild (1938, 1941) and Rankin (1939) but only a few reports present a definite evidence indicating that they are an important factor in depleting the host populations under natural conditions. In this connection mention may be made of the works of Johnson (1920), Wesenberg-Lund (1934) and Cort *et al.* (1941) who have stressed the importance of the larval trematodes in the reduction of the snail populations. In the course of the observations here it was found that *Natica* with warty shell invariably had a higher percentage of infection, as much as 25%, whereas those having normal shell had only 7% infection. Therefore it seems plausible that one superficial effect of parasitism is at least seen in the wartiness of the shell.

Regarding the pathological effects of the metacercarial cysts on their second intermediate host, there seems to be a general belief that they do not appear to harm the hosts even when present in large numbers (Lebour, 1911 ; Sewell, 1922 ; Harper, 1929 and Rothschild, 1941). On the contrary the present investigations on the host-parasite population (as depicted in Graph B) seems to suggest that the fall in the strength of the host population is related to the harmful effects of the metacercaria. Lal and Baugh (1955) have shown that the development and growth of the metacercaria affected the normal functioning of the organs of *Vivipara bengalensis*. In the mantle, the infection retarded its normal elastic function.

Cercaria and metacercarial cysts of the species *Echinochasmus* affect two distinct hosts—a snail and a bivalve respectively, both of which occupy a common mudflat. In Graph A it can be seen that the population of the host and the cercarial population continue to rise, the former reaching a maximum between February and March. However, at the conclusion of the first cercarial peak in February-March, the rise of *Natica* population is drastically checked and there is a steep fall of nearly 67% in the population of this host, which is prevented from making a further recovery by a second cercarial peak falling in May. The host population from now onwards continues in this low ebb for nearly five or six months after the initial fall. From July onwards when the cercarial population also falls, a gradual recovery of the host population can be seen which continues to rise and repeat the process in the following year. A similar trend in the population of *Physa parkeri* due to the trematode larval infection was observed by Cort *et al.* (1941).

In Graph B, with reference to the second intermediate host the interpretation of the data will follow more or less on the same lines. The general trend shown in the host population curve is that it forms a peak between February and March and after which there is a sudden fall of over 60% and an increase in the population is seen being built up by May. But subsequently there is a steady fall both in the percentage of infection as well as in the population. The fall of the host population begins when the population of the parasite reaches the maximum and the recovery of this host population takes place with fall of the population of the parasites. But what is most striking in both these figures is the near identity of the intensity of percentage of infection. This really indicates that the population of the parasites are of the same order since one gives support to the other. If the depletion of the host population is due to any extraneous environmental factor operating in the mudflat, it should affect the parasites together with their hosts.

Summary

1. Morphological descriptions of cercaria, redia, metacercaria and adult *Echinochasmus bagulai* are presented.

2. The development of the marine cercaria and metacercaria to the adult *E. bagulai* is described. Incidentally this is the first record of a marine cercaria and a metacercaria from India.

3. The two-year data on the ecological studies of the larval trematodes of *E. bagulai* have been analysed with reference to the host-parasite relationship and the effect of parasitism on the population.

Acknowledgments

I am indebted to Dr. N. K. Panikkar, Fisheries Development Adviser (formerly the Chief Research Officer, Central Marine Fisheries) and Dr. S. Jones, the present Chief Research Officer, for all their help and encouragement shown to me during the course of my work at the Station. I thank Dr. S. V. Job for having gone through the manuscript and for his suggestions. To the Ministry of Education, Government of India, I owe my thanks for the award of the Senior Research Scholarship.

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Abbreviations

b.p.	birth pore	ot.	ootype.
cir.	cirrus	ov.	ovary.
co.	collar	pen. g.	penetration glands.
c.g.	caudal gland	ph.	pharynx.
cir. p.	cirrus pouch	p.g.	prostate glands.
c.e.d.	caudal excretory duct	p.r.	prostate reservoir.
d.ej.	ductus ejaculatorius	pr.	procruscula.
e.v.	excretory vesicle	sh.gl.	shell glands.
ex.gr.	excretory granule	t.1	anterior testis.
f.g.p.	female genital pore	ut.	uterus.
g.	gland	v.d.	vas deferens
int.	intestinal limb	v.s.	vesicula seminalis.
l.e.c.1	lateral excretory canal (main canal)	vit.	vitellaria.
l.e.c.2	lateral excretory canal (seconday canal)	vit.d.	vitelline duct.
l.e.c.3	lateral excretory canal (tertiary canal).	vit.res.	vitelline reservoir.

J. Mar. biol. Ass. India, 1960, **2** (1) : 51-52

NOTES ON ANIMAL ASSOCIATIONS. 2. THE SCYPHOMEDUSA, *ACROMITUS FLAGELLATUS* STIASNY AND YOUNG *SELEROIDES LEPTOLEPIS* (CUVIER & VALENCIENNES) WITH THE LATTER FORMING A VANGUARD

By S. Jones

Central Marine Fisheries Research Station, Mandapam Camp

Instances of young fishes swimming under the umbrella of jellyfishes and taking refuge in their subgenital cavities and grooves at the base of the mouth arms when alarmed are well known. The fishes associated with medusae are mostly carangids and gadids. Panikkar and Prasad (1952) have described the association between *Rhopilema hispidum* Maas and the young of *Caranx kalla* Cuvier & Valenciennes. The association described in the present article differs from the previous records in that the fish were found to move in advance of the medusa as a vanguard.

On 28-4-1960 at about 7.00 a.m., while making underwater observations with the help of mask and snorkel on an interesting case of association between an alpheid and a gobiid fish, which will be described in a subsequent number in this series, my attention was directed to a jellyfish in the neighbourhood by Mr. P. V. Ramachandran Nair, one of my colleagues, who had accompanied me. In association with it were a number of small fish which unlike in other recorded cases remained above the umbrella of the jellyfish and moved in advance in jerks pausing intermittently and in rhythm with the movement of the medusa. The fish kept themselves close to the medusa but not in actual contact with it. Their movements were so well synchronised that it would appear that the fish, which were never seen to turn round or make any special attempt to check the position of the jellyfish, could anticipate the direction in which and the distance to which the latter would move.

The medusa was of light pinkish colour and in the clear water the silvery sheen of the fish reflected brightly against the morning sun and the whole scene presented a most interesting sight through the magnified view offered by the mask. The jellyfish was capable of active movement and attempts made to separate the fish from it did not meet with complete success. Whenever some got scattered or separated from one another they lost no time in re-forming into a compact group ahead of the medusa to resume the characteristic movement in 'fits and starts'. On the particular day I had taken with me an artist who was provided with a mask and snorkel for assisting me in making underwater diagrams and we followed the medusa and the associated fish for a considerable time to observe their behaviour. The drawing made by him is given in Plate I.

The medusa and the fish were brought to the laboratory to be photographed alive but though the former remained in good condition and showed active movements within the confines of a small jar, all the fish died except one. The surviving fish despite signs of exhaustion strived to keep itself ahead of the medusa. The jellyfish was identified as *Acromitus flagellatus* Stiasny, a common medusa on the East Coast of India (Menon, 1930) but apparently not very common in the Gulf

of Mannar or Palk Bay. The preserved specimen has a diameter of 110 mm. and the excumbrellar surface bears numerous brown spots. The associated fish were the young of *Seleroides leptolepis*, a common carangid in the Palk Bay. There were 32 specimens in all measuring from 10.6 to 30.0 mm. These are being described elsewhere.

On the same day, a small specimen of *Mastigias papua* L. Agassiz with two young specimens of *Carnax kalla* under the umbrella were collected and the above are shown on the right hand top corner of the drawing (Plate I). In this case it could be said that the fish might derive some benefit by way of protection from enemies. Similar association with carangids have been noticed in a few other species of medusae also in this area.

Annandale (1915) described from the Chilka Lake *Acromitus rabanchatu* which resembles very much the above species. Unlike *A. flagellatus* this appears to be a 'sluggish medusa' with slow and feeble pulsations and with the stinging cells having 'little or no effect on the human skin.' Though found in large numbers both in brackish waters and in the sea, no instance of any fish in association with *A. rabanchatu* has been reported so far.

In the present case the exact significance of the association is not known and any explanation could only be matter of conjecture. The question of protection to the fish as in other recorded cases does not arise here since they swim in advance of the medusa. It will be interesting if observations could be made on *A. flagellatus* elsewhere to see if the same type of association is a common feature and also if there is any specificity in partnership.

My sincere thanks are due to Messrs. P. V. Ramachandran Nair and C. Sankarankutty who accompanied me and helped me in making these observations. I am grateful to Dr. R. Raghu Prasad for kindly identifying the two medusae for me.

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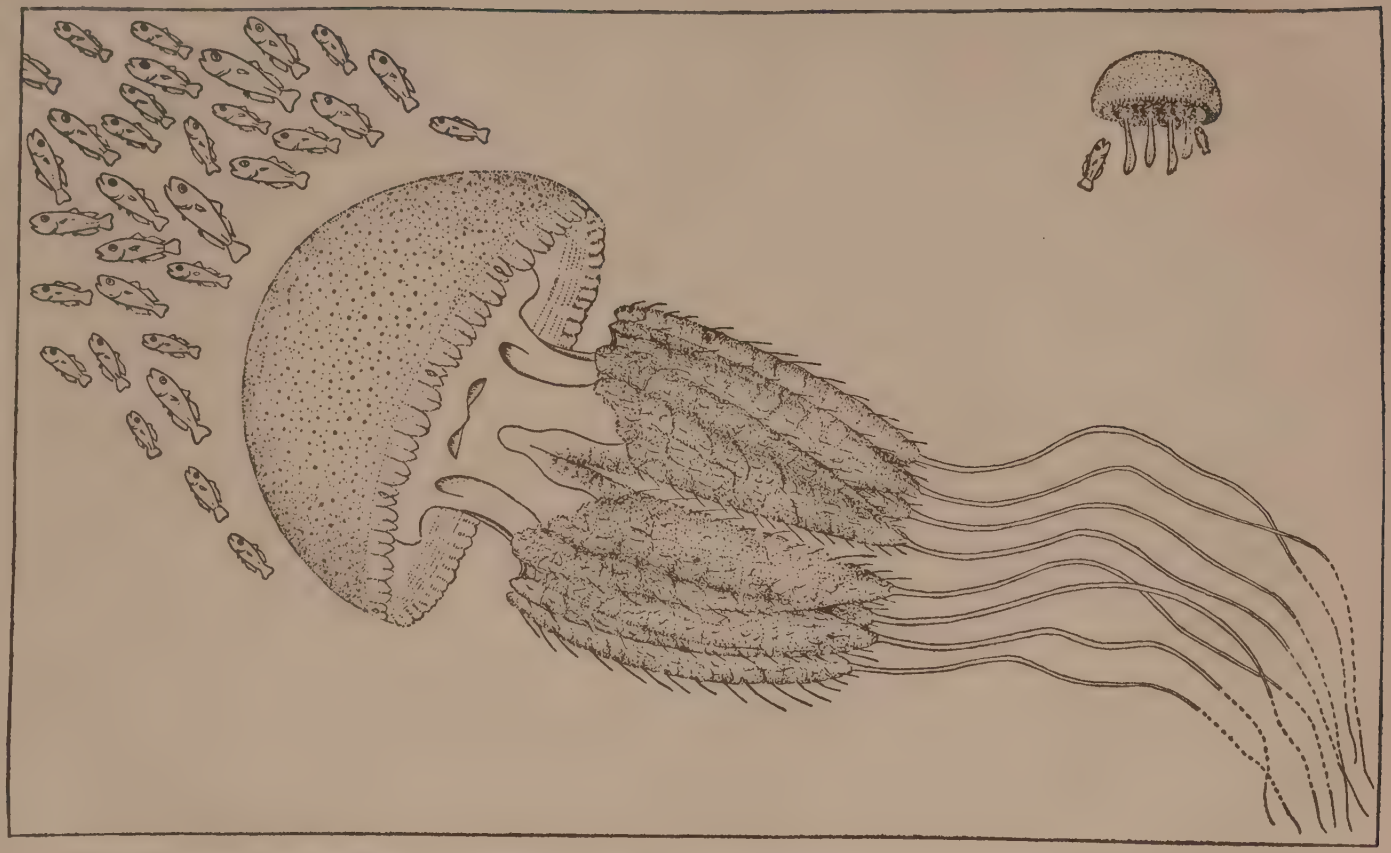

PLATE I : A semidiagrammatic view of the association between *Acromitus flagellatus* and *Seleroides leptolepis*. On the right top is shown *Mastigias papua* in association with two young *Caranx kalla* (By Mr. K. L. K. Kesavan)

J. Mar. biol. Ass. India, 1960, **2** (1): 53-56

ON THE EARLY DEVELOPMENT OF *PROTULA TUBULARIA* (MONTAGU)

(Family Serpulidae—Polychaeta)*

By P. R. S. Tampi

Central Marine Fisheries Research Station, Mandapam Camp

The growth of serpulid polychaetes inside marine aquaria and the consequent need for their frequent cleaning is a common experience. Ever since the experimental aquarium of the Central Marine Fisheries Research Station has been in operation, where unfiltered sea water is being circulated, a large number of serpulids were observed to grow either as solitary individuals or sometimes in clusters inside the concrete tanks, particularly in the less illuminated corners and grooves. These were carefully scrapped out from the substratum and were identified as *Protula tubularia* (Montagu), a species widely known from circummundane areas. However, since Willey (1905) recorded this species from the Ceylon Pearl Oyster beds and described it as *Protula* (*Protulopsis*) *palliata* (but considered as a synonymy of *Protula tubularia* by Fauvel in 1953), there do not seem to be other collections from the Indian Ocean. The Indian Museum material includes only the anterior portion of a specimen of *Protula* from Andamans whose specific identity had not been ascertained (Fauvel, 1932). Owing to the hardy nature of the eggs and the ease with which they can be reared in the laboratory, serpulids have received comparatively greater attention among polychaetes as regards their development. For a review on the subject the reader is invited to the account on the development of *Pomatoceros triqueter* by Segrove (1941). It is apparent from literature that similar studies on tropical species are lacking and, therefore, a brief description of the early development in *Protula* is given below.

Development of the Egg and the Early Larva

Eggs were found at the bottom of the bowl in which freshly collected worms were kept. The fertilized egg (Fig. 1) is spherical with a diameter of 80-85 micra, including the egg membrane which is about 2 micra thick. The egg has a light pink coloured yolk as in the eggs of *Hydroides norvegica* (Paul, 1942), and numerous oil globules. The division of the egg started about an hour and a quarter after collection. The egg first divides horizontally into two unequal cells (Fig. 2) and within another fifteen minutes the 4-celled stage is formed. Out of the four cells thus produced one is comparatively large (Fig. 3) and this indicates the eventual posterior end of the larva. This cell more or less retains its relatively large size throughout the subsequent stages of division. Cell division is fairly rapid and the 16-celled stage (Fig. 4) is produced within an hour while subsequent stages have been difficult to follow owing to the opaque nature of the yolk. Within another two hours

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the gastrula is formed which soon develops an apical tuft of short cilia (Fig. 5, *ap.t.*) and the whole embryo starts a gentle revolving movement on its vertical axis. At this stage the oil globules begin to coalesce into larger and consequently fewer ones and the whole embryo loses its spherical shape. After about four hours since starting segmentation the indication of a protroch becomes evident in a horizontal plane around the embryo which begins to elongate (Fig. 6) and the spinning movement is accelerated. The number of oil globules is considerably reduced which show a maximum diameter of 20 micra. The egg membrane is never seen to be shed during the transformation of the egg into the embryo and, as in the case of many other polychaete development, the egg membrane is believed to be retained eventually to become the cuticle of the larva.

A free-swimming trochophore shown in (Fig. 7) has an average length of 150 micra excluding the apical ciliary tuft, has a well developed prototroch (*pr.*) of long cilia and also an anal tuft (*an.t.*). A ventral ciliary band or the neurotroch consisting of very short cilia is present which can be seen only from the side or in a ventral view. Two brownish eye spots are present near the anterior region. The yolk becomes more frothy and slightly translucent. (Fig. 8) shows the free-swimming larva on the second day. It has almost the same length as the trochophore but possesses a round head with slightly thicker cuticle than on the rest of the body and bears the two eyes spots. The apical and anal tufts have disappeared while the prototroch helps the larva to swim about actively near the surface of water. Two setigerous segments, each with a pair of simple setae, are present. Two anal vesicles (*an.v.*) can be distinctly seen at the posterior end of the larva.

Very little external changes in the larva are noticeable until about the third day of its free-swimming life except an increase in the swimming activity and a tendency for the post-trochal region to elongate. By about the fourth or fifth day (Fig. 9) distinct changes including a shrinkage of the head which becomes more square than round, a retrogression in the prototrochal cilia, disappearance of the neurotroch, formation of the rudiments of the collar fold (*c.f.*), appearance of the third setigerous segment and a further reduction in the number of oil globules. The anal vesicles are not clear and it is not certain whether they disappear completely at this stage or not. The whole larva is more transparent and the formation of the alimentary canal within can be seen through the body wall although it is doubtful if the digestive system becomes functional at this stage. Accompanying these external changes the larva also shows a tendency to rest occasionally at the bottom. Further observations of the larvae have not been possible as the larvae in this series did not survive under the conditions.

Discussion

Comparing the early development of this species with that of other serpulids from the temperate waters, it may be seen that while there is remarkable similarity in the general mode of development in the various species, the duration of the progressive changes in the early phase and in the free-swimming larval life in the present species is considerably abbreviated. Segrove (*op.cit.*) has discussed this point in his account on *Pomatoceros* development where the prolonged larval life and some of the morphological characters are attributed to the relatively small and poorly yolked egg. While the egg of *Protula* is rich in yolk, the size of the egg compares more or less in the two species. Both the trochophore and the early larva in *Pomatoceros*

Text-figure 1. The fertilized egg of *Protula tubularia*.
Text-figures 2, 3 & 4. Tne 2-celled, 4-celled and 16-celled stages, respectively.
Text-figures 5 & 6. Two stages in the spherical ciliated larva, the latter with the prototroch.
Text-figure 7. The free-swimming trochophore.
Text-figure 8. Larva on the second day.
Text-figure 9. Larva just before settling.

are much more organised than in the present form which lacks in a mouth, the feeding cilia and the alimentary canal during its free-swimming life which, as pointed out by Segrove, can be due to the complete dependence of the larva on its reserve yolk. Similarly, the larva of *Pomatoceros* possesses an additional circlet of metatrochal cilia and the advanced larva at the time of settling possesses four setigerous segments. The differences in the number of anal vesicle may not be very significant as this structure is known to vary in number in the different species of larval polychaetes.

Protracted embryonic development and larval life under colder conditions, both among the invertebrates and vertebrates, is well known. It may be pointed out here that the observations of Segrove on *Pomatoceros* has been carried out under 18°C. and the free-swimming larval life of the species is about 3 weeks while in the present instance where studies have been made at a water temperature of 26°C. the whole larval life is undergone in about 4 or 5 days when the larva begins to settle at the bottom. The absence of the digestive system and the complete dependence of the larva on its yolk reserve is also significant and a detailed study of the internal morphology will be of special interest. Paul (1942) while studying the growth and breeding of sedentary organisms in the Madras harbour has reported that *Hydroides norvegica*, a common serpulid, grows rapidly and attains maturity in a remarkably short time of 9 days after the larva settles down while the same species takes nearly 4 months to mature in the Plymouth waters (Orton, 1914) which, as Paul has discussed in detail, is possibly caused by the difference in temperature between the two regions. This perhaps indicates the effect of increased metabolic rate at higher temperatures.

Summary

The early larval development of *Protula tubularia* (Montagu), a serpulid polychaete, is briefly described. The salient features in the development are compared with that of allied species from temperate waters and their significance discussed.

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STUDIES ON THE SHRIMP *CARIDINA LAEVIS* (HELLER)

1. The Digestive System

By R. Sridharan Pillai*
Department of Zoology, University College, Trivandrum

Introduction

Except for a few papers on the structure of the foregut and the physiology of digestion in a few forms, no comprehensive account exists on the detailed anatomy of the alimentary canal and associated glands of the Crustacea of India. Patwardhan (1935) has made a comparative study of the foreguts of quite a number of Decapods including eighteen species of Caridea. Later (Patwardhan 1937) the digestive system of *Palaemon malcolmsonii* was described by him. The physiology and cytology of digestion in *Paratelphusa hydrodromus* was studied by Reddi (1937, 1938). A detailed account of the anatomy of the digestive system and the physiology of digestion and assimilation in *Nephrops norvegicus* was given by Yonge (1924). The nature and permeability of the chitinous layer of the foregut in Decapoda have been elucidated by him in 1932. The anatomy and histology of the digestive system of *Galathea* was worked out by Pike (1947). Jacobs (1928) and Weel (1955) have made important contributions to the cytology and physiology of the digestive diverticula in *Astacus leptodactylus* and *Atya spinipes* respectively. In the present paper an attempt is made to describe the detailed anatomy and histology of the digestive system of a Caridean shrimp. *Caridina laevis* was chosen in view of its easy availability and extreme hardiness.

Material and Methods

Caridina laevis is abundant in ponds and lakes with plenty of vegetation and clean water. Specimens were collected with the help of a common ring net made out of mosquito netting. The animals were reared in a $20'' \times 10'' \times 10''$ glass aquarium containing pond water with vegetation (*Hydrilla* and *Elodea*) and sand. Tank water was found most suitable though tap water had no visible detrimental effects. The aquarium was installed in such a way that direct sunlight was available for about a couple of hours every day and the water was changed once in four days.

The gross anatomy of the digestive system and the structure of the stomach were studied by micro-dissection under a stereoscopic binocular microscope in artificial illumination. Histology was studied by sectioning the different regions of the animal. The exoskeleton being soft enough, animals were easily cut by the methyl-benzoate-celloidin technique (Pantin 1948). Different stains and techniques were employed which are dealt with in the appropriate places.

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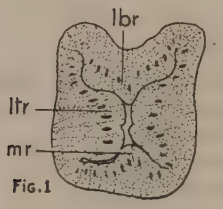
* Present address : Zoological Survey of India, Calcutta-12.

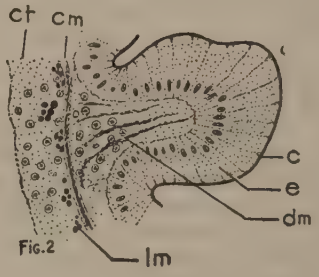
1. The Foregut

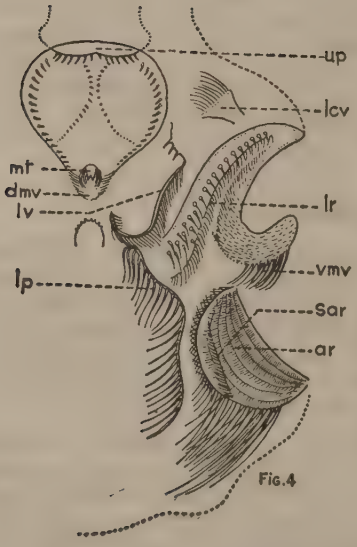
The mouth is a longitudinal narrow slit opening into the food basin (the space enclosed by the maxillipeds, Manton 1928). The oesophagus leading from it is a short vertical tube 260μ long and 120μ wide maximally.

Structure of the oesophagus (Fig. 1)

The oesophagus is squarish in section and presents three ridges inside. The labral ridge (lbr) is continuous with the labrum. The lateral ridges (ltr) are broader.







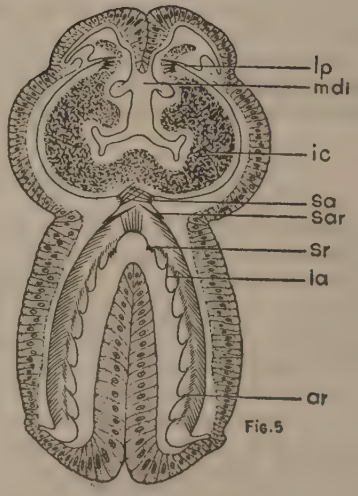


Fig. 1. C.S. of oesophagus through its distal part.
Fig. 2. A portion of the oesophageal wall.
Fig. 4. Inner view of cuticular wall of the stomach after cutting through the median ventral line of the pyloric stomach.
Fig. 5. A vertical section through the anterior part of the pyloric stomach.

The hind wall of the oesophagus is devoid of a ridge proximally, although, distally a small ridge, the metastomal ridge (mr) makes its appearance. The lumen of the oesophagus is X-shaped because of these ridges which fade out imperceptibly where the oesophagus opens into the stomach.

Histology (Fig. 2)

The wall of the oesophagus is lined internally by a thin layer of cuticle (c). Outer to this is the epithelial layer (e) made up of columnar cells. The cells are about 55μ long with clear cytoplasm and small oval, basal nuclei. Surrounding the epithelium is a connective tissue envelope (ct) which extends into the core of the oesophageal ridges. Circular (cm), longitudinal (lm) and dilator muscles (dm) of the oesophagus are found in close association with the connective tissue layer.

A few glands have been observed in the wall of the oesophagus. Their structure is quite similar to that of the tegumental glands and will be described in a subsequent communication on the integument.

Structure of the Stomach (Figs. 3, 4, 5 & 6)

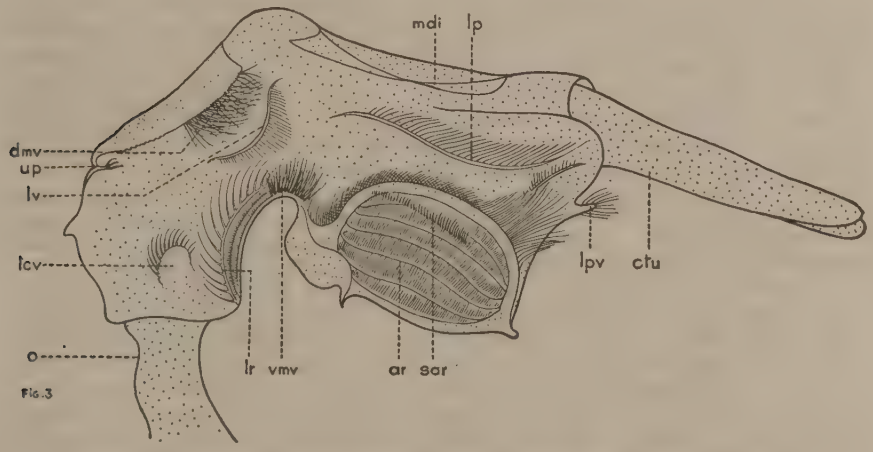


Fig. 3. Lateral view of stomach after removal of muscles and other soft tissues.

Methods

Stomachs from starved animals were treated with a weak solution of KOH and the soft tissues teased off under water. The structure of the cuticular lining was studied in reflected light under the low power of the microscope. These observations were confirmed on sectioned material and exuviae.

Out of the two divisions of the stomach *viz.* cardiac and pyloric, the latter is larger being 0.7 mm. long and 0.5 mm. high in an adult female specimen, while the cardiac stomach is 0.5 mm. long and 0.3 mm. high. The median dorsal wall of the cardiac and pyloric divisions is depressed into their lumen except at the region of the cardio-pyloric junction.

The proximal part of the cardiac stomach is rectangular clearly demarcating the oesophageal portion(o) from it. Beyond and on either side of the opening of the oesophagus, the cardiac walls bear two roughly triangular valves (lcv). The fore end of the cardiac roof bears a faintly notched median transverse plate (up) abutting into the lumen and bearing a few short bristles at its free margin. Between this and the cardio-pyloric opening, the cardiac roof is heart-shaped and depressed. Its tapering hind end is infolded backwards below the roof of the cardio-pyloric opening. This bears a tubercle with two small teeth at its tip (mt) which might correspond to the median tooth of other decapods. On either side of this median tooth are two clusters of long bristles, extending into the cardio-pyloric opening. This is the dorsal median valve (dmv). The floor of the cardiac stomach is convex and consists of a median plate bearing two almost parallel ridges, the longitudinal ridges (lc) bearing two or three rows of bristles directed towards the cardio-pyloric opening. The plate has a coat of velvetty bristles. The hind end of the median plate bears a cluster of short bristles which constitutes the median ventral valve (vmv). The lateral wall of the cardio-pyloric opening has a crescentic thickening carrying bristles and constituting the lateral valve (lv).

The cardiopyloric opening leads into the pyloric stomach whose roof is also depressed into its lumen. The lateral wall of the pyloric stomach has a longitudinal thickening, the lateral pyloric thickening (lp), which extends to its hind end bearing long backwardly directed bristles. Below this it is folded inwards forming the supra-ampullary fold (sa) which divides the pyloric stomach into a dorsal and a ventral chamber. The median part of the floor of the lower chamber of the pyloric stomach is raised into the shape of a median biconvex fold, the interampullary fold (ia) which divides it into two chambers, the ampullae, appearing in cross section like an inverted V. The summit of the interampullary fold and the supraampullary folds bear inumerable long bristles in a criss-cross manner so that the slit-like opening into the lower chamber of the pyloric stomach is converted into a fine sieve thereby preventing the larger particles of food in the dorsal chamber from entering the ampullae and congesting its narrow lumen. The inner wall of each ampulla *viz.* the outer wall of the interampullary fold is raised into eight longitudinal ridges (ar). From each of the lower ridge extends a row of fine silky bristles to the ridge above. The uppermost ridge has a serrated margin (sr) in place of bristles. The outer wall of the ampulla is free from ridges but bears numerous bristles in an orderly fashion. Below the supraampullary ridge, it bears a row of short and stout bristles (sar). The two ampullae diverge anteriorly and lead into a common space, behind the ventral median valve. The opening of the ampullae into the midgut, behind, is guarded by a pair of small lateral valves (lpv).

The roof of the pyloric stomach presents a rhomboid depression (rhd). The fore end of the rhombus involutes below the roof of the cardio-pyloric opening has a pointed double-walled pocket, almost touching the similar semicircular involution from the hind end of the cardiac stomach. On the longitudinal longer diagonal of the rhombus is a narrow deep invagination of the cuticular wall, the median dorsal pyloric infold (mdi). The postero-lateral sides of the rhombus expand on either side into a pair of wings (w). Leading from the upper division of the pyloric stomach are two long half-tubules which together function as a conveyor tube (ctu). The coarser contents of the pyloric stomach are conducted far back into the midgut without their obstructing the openings of the digestive divertcula and the midgut caeca which open immediately behind the pyloric stomach.

Histology

The cuticular lining of the stomach is thicker than that of the oesophagus, but the formation of ossicles does not take place unlike in most other decapods. The epithelium is unilaminar or polylaminar in which case it is thick and lines some of the depressions of the cuticular lining. No muscle fibres incorporated in the stomach wall have been identified.

Gastric Muscles (Fig. 7)

The list of extrinsic and intrinsic muscles, based on the classification of Mocquard (1883) is given below. As far as possible the same terminology has been followed.

A. *The Extrinsic muscles*

1. Anterior gastric muscle.....(ag)
2. Posterior gastric muscle.....(pg)
3. Anterior superior dilator muscle.....(od)
4. Anterior cardiac dilator muscle.....(ac)
5. Anterolateral cardiac dilator muscle.....(cad)
6. Anterior oesophageal dilator muscle.....(aod)
7. Lateral oesophageal dilator muscle.....(lod)
8. Posterior oesophageal dilator muscle.....(pod)
9. Ventral pyloric dilator muscle.....(pd)

B. *The Intrinsic Muscle*

1. Lateral pyloric muscle.....(lp)
2. Longitudinal muscles of the ampulla.....(la)
3. Transverse pyloric muscle.....(tp)
4. Lateral cardiac muscle.....(lc)
5. Tranverse cardiac muscle.....(tc)
6. Posterior inferior cardiac muscle.....(pc)
7. Anterior cardiac muscle.....(ac)

General considerations on the stomach and gastric muscles

Patwardhan (1935) has worked out the structure of the stomach of numerous decapods. The account includes a cursory reference to that of *Caridina brachydactyla* also. It is remarkable that the stomach figured and described by him differs obviously from that of *C. laevis.*

In spite of the fact that some members of the group Penaeidea exhibit complex types of gastric armatures, the Penaeidea is supposed to possess the simplest gastric structure. Bonnier (quoted by Calman 1909) has studied the simple gastric structure of *Cerataspis*, a penaeid. *Caridina* and other members of the tribe Caridea, characterised by the absence of a gastric mill, fall into a group by themselves under Decapoda. The cardiac stomach and the dorsal section of the pyloric stomach of these bear a few important resemblances with those of *Cerataspis.* These are briefly, the median dorsal depression of the cardiac stomach bearing the median tooth, the median ventral plate of the cardiac stomach bearing two parallel ridges, the lateral wall of the pyloric chamber bearing bristles, which in *Caridina* are restricted to

form the lateral pyloric bristles, the posterior part of the pyloric stomach bearing long extensions (the lappets in *Cerataspis* and the conveyor tubes in *Caridina*) and the two smaller valves below these. It is obvious that the stomach of *Caridina* shows greater complexity of organisation than that of *Cerataspis* mainly in the presence of the anterior cardiac valves and the lateral valves (which in *C. brachydactyla* almost assume the proportions of the lateral teeth), a median tooth and the single row of lateral pyloric teeth. Patwardhan (1935) has concluded that the absence of a gastric mill in the members of Caridea is due to its secondary suppression represented by degrees in the series *Caridina*, *Hippolyte* and *Virbius*. This is based on Borradaile's (1907) classification attributing the lowest phylogenetic position to the Penaeidea under Decapoda and the fact that *Cerataspis*, a penaeid, has the simplest gastric armature. But many penaeids have a complex type of gastric structure and hence, until a very thorough comparative account of the stomach of the various decapods is undertaken with a view to elucidating their phylogenetic relationships, the above conclusion of Patwardhan could only be treated as tentative.

There is a paucity of literature on the musculature of the stomach of decapod Crustacea. On comparing the musculature of stomachs with gastric mill with that of *Caridina*, the following conclusions may be drawn. In being devoid of a gastric mill, the gastric musculature of *Caridina* is prone to much variation if not retrogression. The extrinsic muscles have suffered more in this process. The proportions of the more important muscles are reduced and the less important ones even fail to be represented. If the view of Patwardhan is accepted, this must be due to their secondary suppression consequent on the loss of the gastric mill. It is noteworthy that the intrinsic muscles have not changed much ; in fact new ones are represented like the longitudinal intrinsic muscles of the ampulla and the transverse pyloric muscle. What corresponds to the posterior inferior cardiac muscle of decapods extends still further posteriorly and connects the front extremities of the pyloric ampullae. All these would imply the development of new muscles to the pyloric part of the stomach which is outstanding in *Caridina* by its size and organisation.

The working of the stomach and the course of food

During feeding the movements of the stomach may be observed through the transparent cuticle, slightly obscured by the brownish digestive diverticula. The muscles being quite transparent, their individual role in bringing about the desired movements cannot be clearly analysed. The movements of the stomach are of a particular type which are repeated at an average frequency of 32 times per minute. The movements may be analysed in the following order: (1) Lateral walls of the cardio-pyloric junction are apposed. (2) Roof of the cardiac stomach is pulled forwards, slightly narrowing the chamber. (3) Floor of the cardiac stomach exhibits jerky movements backwards and upwards. (4) Two ampullae also pulsate synchronously. The muscles which effect these four types of movements are respectively (1) the transverse pyloric muscles (2) the anterior gastric muscles together with the anterosuperior dilator muscles (3) lateral cardiac muscles and (4) the lateral pyloric muscles together with the longitudinal muscles of the ampulla. The active rôle of the anterior gastric muscles in the contraction of the stomach is disputed. It has been shown to take an active part in forms with a well developed gastric mill (Mocquard 1883 ; Pearson 1908 ; Patwardhan 1935). Huxley (1880) holds that a coordinated working of the anterior and posterior gastric muscles brings about the movements. The rôle of anterior gastric muscle has been questioned by Reddi (1935, 1937) according to whom the posterior gastric plays the important rôle. However this view could not be corroborated in *Caridina laevis*.

The cardiac stomach is seldom found to be completely filled with food particles. The jerky movements of the cardiac floor with its armature resemble the movements of the molluscan radula and transfer the food backwards to the cardio-pyloric opening. When the lateral walls of the cardio-pyloric opening are apposed there is a slight backward pull due to the contraction of the anterior bundle of the lateral cardiac intrinsic muscle. As a result of this the lateral valves of the cardio-pyloric opening play back and forth, backwards when the walls are apposed and forwards when they recede. These movements alternate with those of the median dorsal valve. In other words, when the lateral valves appose the median valve moves forwards and *vice versa*. The food is seen to fill the pyloric stomach completely. It passes on either side of the dorsal median pyloric infold as two streams. Fine particles alone enter the ampullae, which in sections appear as a fine suspension. The two streams of coarser materials in the upper chamber join together behind and are conducted through the conveyor tube far beyond, into the midgut.

The Digestive Diverticula (*Hepatopancreas*)

Methods

Because of heavy secretory activity of the digestive diverticula, the more general types of fixatives do not give a vivid picture of their detailed structure without creating artefacts. Champy's fixative as modified by Weel (1955), Carnoy's and Regaud's fluids were used. Glands fixed in corrosive sublimate-alcohol were also made use of in this study though the results were not good enough. Staining was done in Heidenhain's Azan, Delafield's haematoxylin and Heidenhain's haematoxylin.

The digestive gland consists of numerous blindly ending tubules about 60 μ across, filling up most of the available space inside the cephalothoracic region. There are two main lobes of the gland on either side of the cardiac stomach filling up the thoracic blood sinus. Each lobe consists of a cluster of diverticula which unite to form a number of secondary ducts. The secondary ducts collect together to form the main duct. The two main ducts join together and open into the gut immediately behind the pyloric stomach on its ventral aspect.

Histology

Each tubule of the gland is enclosed in a thin envelope of connective tissue (Fig. 8, ct.) which has numerous extensions which fasten the tubules together and attach them to the surrounding structures. The connective tissue layer is traversed by two types of smooth muscle fibres, the longitudinal and circular, both taking a sky-blue tint in Heidenhain's Azan. The circular muscle fibres are arranged regularly at 10μ intervals and seen to be connected together by a faint network of smaller fibres. The longitudinal fibres are less pronounced and fewer in number which is at variance with the findings of Pump (1914) and Yonge (1924). Beneath the layer of connective tissue is a thin structureless membrane, and then the glandular epithelium of the digestive diverticula. Histologically an apical young region (about 45μ) may be marked off in each tubule representing the embryonic zone (ez). This zone has small, undifferentiated columnar cells measuring about 14μ by 4μ. Nuclei are spherical with more than one nucleolus and a few clumps of chromatin. Most of these cells possess smaller bodies lying distal to the nucleus, *viz.* the parasomes of Jacobs (1928) and minute vacuoles. Mitosis has been observed only very rarely in this zone unlike in *Astacus* (Jacobs 1928). The embryonic zone is followed by the

short transitory zone (tz) where cells are better defined, the cytoplasm slightly spumoid and the nuclei clearly basal. Beyond the transitory zone, the epithelium consists of three types of cells, the Extrusion cells, the Dark cells and the Light cells.

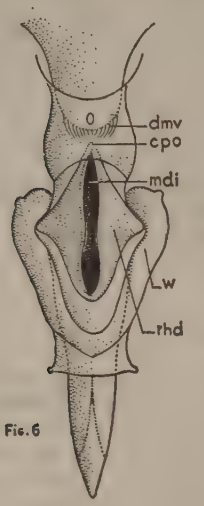


Fig.6

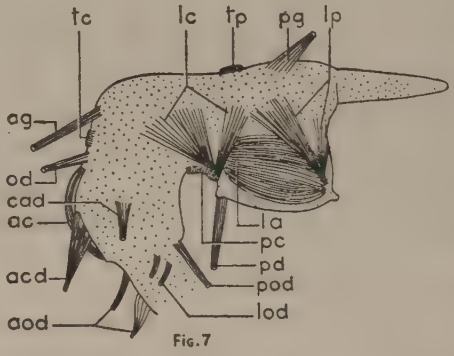


Fig.7

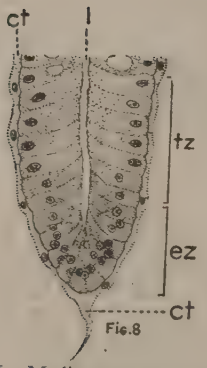


Fig.8

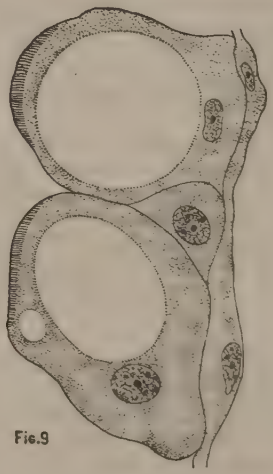


Fig.9

Fig. 6. Median dorsal view of the pyloric stomach.
Fig. 7. Lateral view of the stomach showing the extrinsic and intrinsic muscles.
Fig. 8. L.S. through a tubule of the hepatopancreatic gland.
Fig. 9. Two extrusion cells and a replacement (middle) cell.

Extrusion cells (Fig. 9)

These measure about 35μ by 16μ. A ripe extrusion cell has a large vacuole and a basal nucleus which is crescentic or ellipsoidal with a centrally placed nucleolus. The length of the cell is often determined by the extent of the vacuole and often bulges into the lumen of the tubule. Material fixed in modified Champy's fluid

demonstrates the presence of a faint coagulum and rarely a few crystalloids inside the vacuole. Younger extrusion cells have smaller vacuoles and thicker distal pads of cytoplasm. The apical part of the cytoplasm exhibits faint striations and is better stainable.

Dark Cells

Dark cells have the most life-like appearance in glands fixed in modified Champy's fluid and are rendered markedly more stainable. They (Fig. 10) are as large as the extrusion cells and have larger and more stainable nuclei with excentric nucleoli and numerous clumps of chromatin. The parasomes are often present. Cytoplasm is faintly frothy and presents minute fibrils extending from the base to the apex of the cells. In other fixatives, the dark cells present a different appearance. In Carnoy's fluid the cytoplasm, especially the apical half shows a conglomeration of coarse filament-like structures which are strongly chromophilic. This has been interpreted by Weel (1955) in *Atya spinipes* as artefacts resulting from protein precipitation, representing the typical 'ergastoplasm.' In Heidenhain's Azan, the cytoplasm of the dark cells (Fig. 11) exhibits a pronounced accumulation of dark granules appearing as rings or bodies of other shapes which might indicate a phase of formation of the secretory substance. Thomas (1948) has demonstrated certain azocarminophilic granules inside nerve cells which according to him represent the Golgi spheroids. Though the fixatives employed here are different, the granules and spheroids appear quite alike. Moreover spheroids with an outer more stainable pellicle has been observed in the gland cells vitally stained with neutral red in the present form. This also is in agreement with the findings of Thomas as representing the Golgi complement. In materials stained in Heidenhain's iron haematoxylin, however, this system was not observed.

Light Cells

These (Fig. 12) are strictly columnar cells, narrower than the other cell types described. Nuclei are small, central or partly basal. The cytoplasm is less stainable than the dark cells with strong tendency to vacuolisation and free from any signs of striation.

Smaller cells which measure half the size of the extrusion cells are met within the epithelium which are the replacement cells (middle cell in Fig. 9).

Secretion and Restitution Cycle

METHODS

Freshly collected animals were subjected to complete starvation for 72 hours. In the earlier period of this, water was changed every 15 minutes as the animals are coprophagous. When the gut was rendered empty a few animals were dissected and the digestive diverticula fixed. The other animals were fed on mud and algal filaments. They were killed at regular known intervals and the hepatopancreatic tubules fixed and sectioned. Fixatives employed were Carnoy's fluid and modified Champy's fluid. Both gave tolerably good pictures of the phases of secretory activity of the gland. Stage counting of the various cell types during the different phases of feeding was carried out.

In the hepatopancreas of a normally fed animal, the extrusion cells were more numerous than the dark cells. The lumen of the tubules fixed in Carnoy's fluid

and modified Champy's fluid showed a granular coagulum. The coagulum was absent in animals subjected to 72 hours' starvation. Here the extrusion cells and dark cells showed the same frequency as in a well-fed animal. The extrusion vacuoles were small. In the fed animals after 30 minutes, a faint reduction in the number of extrusion cells has been observed. The vacuoles were much larger and pressed against each other rendering the lumen irregular. In tubules fixed one hour and fifteen minutes after feeding, the frequency of extrusion and dark cells had gone down. However an increase in the number of replacement cells was noticed. Little change had taken place in tubules fixed after one hour and forty-five minutes but for the definite increase in the frequency of dark cells. Their cytoplasm exhibited a uniformly chromophilic granular appearance and the fibrillar nature was represented only sporadically. At 2 hours and 15 minutes after feeding the dark cells demonstrated the fibrillar structure described earlier as the ergastoplasm. A few lingering vacuoles still remained. By about 2 hours and 45 minutes after feeding, there was a marked domination of the extrusion cells over the dark cells. Vacuoles of various sizes, large and small, were seen. The dark cells have either not changed or there was slight reduction. Tubules fixed still later, after 30 minutes, showed an increase in the extrusion cells. Most vacuoles were large, apical and apparently about to be extruded. The lumen of the tubule appeared to be bounded by an array of vacuoles. Dark cells were scarce comparatively. The ripe vacuoles ceased to exist in tubules fixed after four hours and 15 minutes. Smaller vacuoles were abundant and these with the vacuoles that are developed at this stage by the light cells bestowed a ' bubbling ' appearance to the epithelium, obscuring the cellular details and the boundary of the lumen. The bubbling appearance was lost and the boundary of the lumen once more established at about five hours after feeding. The secretory vacuoles of the extrusion cells were not represented except for a few lingering stray ones whose extrusion has been delayed probably by a lack of feeding stimulus. The dark cells may be described to be in the ascendant. In another three hours, the extrusion cells were also on the increase.

With the initiation of feeding, the number of extrusion cells is on the decline indicating a phase of extrusion. This phase lasts for two hours and a half after which the restitution phase commences. This reaches its mode between two hours 40 minutes and four hours 15 minutes. Following this, at about five hours after feeding the second extrusion phase sets in and the next phase of restitution appears to be attained in another three hours. The chronological disposition of these phases is at variance with the findings of Weel (1955) in *Atya spinipes* where the number of extrusion cells reaches its peak during the first 30 minutes after feeding has started, followed by a minimum at four hours. A second maximum is attained at 12 hours. Synchronous with the initiation of feeding there is a sharp rise in the number of extrusion cells in *Atya* while in *Caridina* they are on the decline. The secretory cells of the digestive diverticula are polyphasic, to use the terminology of Hirsch (1931). The secretion is merocrine unlike that of *Astacus* (Hirsch and Jacobs 1930).

The phenomenon of secretion and restitution of the gland cells of the hepatopancreas has been elucidated by Hirsch and Jacobs (1929, 1930), Jacobs (1928) in *Potamobius leptodactylus* and Weel (1955) in *Atya spinipes*. In *Potamobius*, Jacobs has observed a direct transformation of the light cells and dark cells into extrusion cells. Such a transformation of the dark cells into extrusion cells is not apparently

found in *Atya*. In *Caridina*, the stage counting shows that the dark cells and extrusion cells at any given time show an inverse relation, i.e., when one has a high frequency the other has a low one. The dark cells get directly transformed into the extrusion cells unlike in *Atya*. The smaller cells met within the epithelium are the replacement cells described in various other Crustacea (Yonge 1924, Pike 1947, etc.). The replacement cells in *Nephrops* are thought to take the place of old discarded cells. In tubules fixed one hour after the initiation of feeding, the count of the extrusion cells has gone down with the dark cells in *Caridina*. The increase in the replacement cells at this stage may be correlated with the decrease in the number of extrusion cells. The replacement cells may thus be derived from the extrusion cells after their phase of extrusion. Mitotic figures were not observed either. The transformation of the light cells into the extrusion cells cannot be ascertained as they exhibit little change in count during the phases of secretion and restitution.

Mechanism of extrusion

Stained sections of the digestive diverticula suggest clearly a discharge of vacuolar contents of the extrusion cells by rupture. The lumen of the hepatopancreatic tubule contains a lightly staining coagulum possibly formed by the secretory contents and fine food materials. Reddi (1938) has shown in *Paratelphusa* that the zymogen region of the secretory cells either ruptures or dome-shaped structures are detached *en masse* into the lumen. Such cytoplasmic extrusions are met with in *Caridina* also, although they do not seem to incorporate secretory products. It is possible that these, as has been shown by Owen (1955) in the diverticula of *Cardium edule* might serve to convey indigestible material out.

Duct of the digestive divertucila

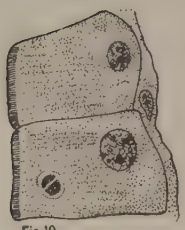
The epithelium of the main duct measures about 18-20 μ in thickness and the lumen about 90μ. The cells are columnar and have large spherical or elongated nuclei with usually two nucleoli. A few cells appear as binucleate. Histologically the duct resembles the tubule of the diverticula. The outer connective tissue envelope of the tubule is continuous with that of the secondary and main ducts.

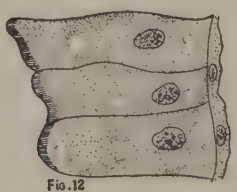
2. The Midgut

The chitinous lining of the foregut terminates in the region of the pyloric stomach, immediately in front of the origin of the midgut caeca (*vide infra*). The midgut is long and extends upto the last segment. It is strange that the posterior valves of the stomach in *Caridina brachydactyla* (Patwardhan 1935) extend into the hindgut in which case the midgut should be very short.

Histology (Fig. 13)

Enveloped by an outer thin connective tissue layer (ct) are two layers of closely arranged muscle fibres, the longitudinal and circular. Beneath this is a wavy basal membrane and then the epithelial cells (e) of the midgut. The nuclei of the midgut epithelial cells are elongated or oval with usually two nucleoli. Free ends of cells exhibit fine striations. Scattered among the epithelial cells are the spherical compact basal cells (b) (Frenzel 1885) which have been observed in various stages of amitosis. The midgut is divisible into three zones. An anterior zone behind the digestive diverticula distinguishable by the short uneven epithelial cells which are only very faintly stainable. The middle zone has columnar, deeply stainable cells





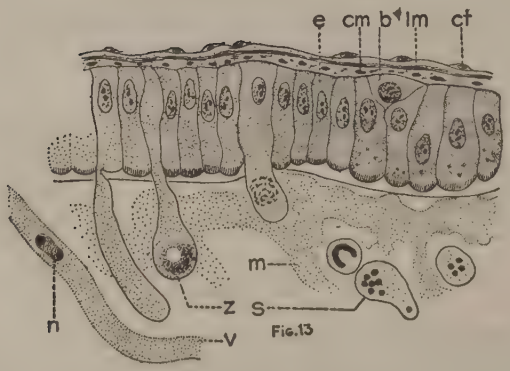


Fig. 10. Dark cell (Modified Champy's fluid).
Fig. 11. Dark cell (Heidenhain's Azan).
Fig. 12. Light cells.
Fig. 13. L.S. through wall of midgut.

measuring about 25μ by 3μ. The posterior zone is constituted by less tall (15μ) but stouter (5μ) cells arranged uniformly. These stain, less intensely than the preceding zone.

Though the epithelial layer of cells of the midgut appear as homomorphous, they show a difference in functional physiology. This is evident on studying the epithelium of the empty midgut in which secretory and non-secretory cells are seen. Numerous spherical or oblong cytoplasmic bodies (s) measuring from 4μ to 20μ are noticeable inside the lumen in all the three zones of the midgut (Plate : Fig. 1).

These are enucleated and contain one or more vacuoles of varying sizes and sometimes a few granule-like concretions. The contents of the majority of the vacuoles at this stage stain red and a few orange in Heidenhain's Azan. In others, part of it alone stains appearing as crescentic or ring-shaped figures. Examination of numerous midgut sections has made it possible to state that these have been formed from some of the midgut epithelial cells. Primarily such epithelial cells show an aggregation of granules, stainable red in Azan, towards their zymogen region (z). The zymogen region is later nipped off into the lumen of the midgut. The granules which apparently represent the secretory products, organise to form vacuoles preceding or succeeding the separation of the zymogen region. The bifold stainability may be explained as due to a slight variation in the chemical composition of the vacuolar contents in its various phases of formation which consequently demonstrates its constitutional affinity, either to azocarmine or orange G. In the midgut of *Glossina* (Wigglesworth 1929) and in the dragon fly nymph (Needham 1898), cytoplasmic globules of a similar nature have been observed to be discharged after feeding.

Lying loose inside the two posterior zones of the intestine are elongated ' vermiform bodies ' (Plate : Fig. 2). These (Fig. 13, v) have a very fine granular cytoplasm which stains a light bluish-red or faint pink. Some of the largest of these measure 80μ by 5μ. Their body is homogeneous without any vacuolisation. In most of these an elongated nucleus-like body (n) about 4μ in length is noticeable. In many of these vermiform bodies, a disintegrating ' nucleus ' with a well-defined 'nucleolus' (1μ across) is clearly observable and in others only the ' nucleolus'. Faint connections between the vermiform bodies and the epithelial layer have been noticed in certain regions of the midgut. At present, it can only be stated that these vermiform bodies are formed by the transformation of a part or whole of some of the epithelial cells accompanied probably by nucleolar extrusion, mostly by disintegration of the rest of the nucleus. Later these bodies spread out to form a matrix inside the lumen.

As far as is known, in none of the Crustacea, reference to such structures has been made. Howells (1942) has described the mucous cells in the salivary glands and in the intestine of *Aplysia punctata*. The mucous cells have been observed to extend into the lumen of the intestine as elongated structures and discharge mucus in masses. Though not drawing a close parallel, it may be stated that the extension of the mucous cells bears a resemblance with the vermiform bodies seen in the midgut of *Caridina*. The spherules of cytoplasm containing either vacuoles or granules referred to before are also found inside the intestine of *Aplysia* (by the same author) in which a few of the gland cells with secretory granules at their tip extrude these into the lumen where the granules swell into thin-walled vesicles. These granules also stain bright red in Azan and the vesicles are supposed to bind the loose intestinal contents into solid faeces.

Animals with empty intestine were tested for mucus using Lillie's method (Cowdry 1952). The result was positive to the matrix and the vermiform bodies. This was confirmed by Mayer's mucicarmine (Cowdry 1952). The mucus from the vermiform bodies binds the faecal matter and this is why the cylinder of extruded faeces, even when divested of its peritrophic membrane, retains its shape in water for a long time.

Following the discharge of the secretory contents, the epithelial cells enter into a period of rest and exhibit signs of atrophy of the nuclei. Later when the intestine

is rendered empty due to continued defaecations, the atrophying cells are seen to be detached into the lumen of the midgut. In some cases very heavy sloughing of the cells has been observed giving rise to masses of cells inside the middle zone of the intestine. This delamination of the midgut epithelium suggests cylic secretory activity and it is assumed that the secretion of the midgut epithelium is holocrine unlike the hepatopancreatic cells.

The peritrophic membrane investing the faecal pellets is extremely thin and transparent. Its property of solubility in concentrated acids and insolubility in concentrated alkalies conforms to that of chitin. The chitosan-idoine colour reaction gives a faint violet colour showing that in constitution, it is similar to chitin. This is in order with the findings of Forster (1953) in some carideans.

Midgut caeca

Midgut caeca consist of three blind diverticula on either side. The middle one is longer and the other two smaller ones are attached to the base of the former. The middle caecum has a small outgrowth just behind its apex. The maximal length of the caeca is 0.65 mm. The two caeca on either side open into the anterior dorsolateral part of the midgut. Histologically the cells of the midgut caecum resemble closely those of the midgut.

3. The Hindgut

The hindgut commences from the hind end of the midgut in the middle part of the last abdominal segment and is about 0.85 mm. long in an adult female. Separating the midgut epithelium from the hindgut epithelium is a narrow gap where the basal membrane is exposed (Plate : Fig. 3). The junction is devoid of a caecum. The hindgut takes a gradual slope and opens out by the anus on the ventral side of the base of the telson. At its commencement the lumen of the hindgut is narrowed by the development of a thick circular pad (sp) formed by the elevation of the epithelial cells with a core of circular and radial muscle fibres inside. The disposition of the muscles clearly points to this structure as a sphincter which controls the entry of the contents of the midgut into the hindgut. It is 80μ thick and 22μ high. The hindgut is lined by a layer of cuticle which at the hind margin of the sphincter bears a few claw-shaped spinules (s). Rectal valve of a similar nature does not seem to have been described in any Crustacea. In *Calliphora* (Insecta) Graham-Smith (1934) has observed a similar valve with backwardly directed spines. The spines seize the peritrophic membrane and pass it backwards by a series of movements. In *Caridina*, the function of the spinules is not clear although it is probable that they seize the peritrophic membrane and arrest its progression which helps in the concentration of faecal matter before it is expelled. Behind the sphincter are six longitudinal ridges of the rectal epithelium, the rectal pads. Two are dorsal, two lateral and two ventral. The dorsal ones are enormously developed compared to the others, extending deep into the lumen.

Histology of the hindgut

The connective tissue envelope and the outer longitudinal muscle are extremely reduced. The circular layer of muscles assumes better proportions. Restricted to the core of the rectal pads are bundles of longitudinal muscle fibres embedded in connective tissue. These bundles extend fan-wise inside the sphincter so that the

valve and the rest of the hindgut function as a single unit. The epithelium of the hindgut is less inclined to be columnar than that of the midgut. Radial muscles connecting the inner cuticular lining of the rectum with the exoskeleton at its hind end function as dilator muscles.

The anus opens at the summit of a small papilla situated in between the bases of the uropods on the anteroventral part of the telson. It is a longitudinal slit with a pair of tumid lips. The faecal pellets are passed backwards below the telson which presents a ventral longitudinal excavation.

Anal Intakes of Water and Defaecation

Methods

Being transparent, *Caridina* permits direct observation on the anal intakes of water. Animals collected from the aquarium were observed under the stereoscopic binocular microscope in transmitted light. They were either kept in a small quantity of water or were fastened to glass slides gently by rubber bands to facilitate continuous observation. The count of anal intakes of water was made with the help of a counter. Animals kept in a suspension of fine charcoal were seen to take in particles of carbon during rectal swallowing.

The number of anal intakes of two specimens A and B are given below in the table.

Table

Animal A

Number of anal gulps per minute

8	7	7	8	7	8	8	9	9	9	11	9	11*
19	18	14	12	11	10	9	8	9	7	12	11	
11	11	11	11	10	11	12	10	11	11	11		
10	12	12	12	11	12	12	12	11	12	13		
12	11	10	12	11	11	11	11	12	11	12		
11	12	12	12	11	10	11	13	13	12	12		
12	12	12	13	12	12	12	11	12	11	11		
12	11	11	12	11	11	11	11	*	18	18		
14	13	12	11	9	11	9	10	11	12			

Animal B

Number of anal gulps per minute

20	22	22	20	23	*	35	*	37	*	32	*
34	30	30	21	20	23	23	22	*	30	*	
42	*	39	*	37							

(Each asterisk represents one defaecation)

In animal B, the number of intakes immediately after defaecation was calculated for one minute, because successive defaecations took place within fractions of a minute.

When the midgut is full, the middle zone is narrower than the anterior or posterior zones. The wall of the midgut exhibits antiperistaltic waves. There is regular anal intake of water. The two lips of the anus move out engulfing a minute spindle of water which is sent forwards in between the two conspicuous dorsal pads of the rectum. Prior to the process of defaecation the number of anal intakes becomes constant in a particular animal (animal A). But this frequency is seen to vary with different animals (animal B).

During defaecation, the rectum is dilated and the increased pressure inside the intestine drives the faecal matter into the rectum as far as the anus which is kept closed. The sphincter with its circlet of spinules now contracts serving a faecal pellet from the cylinder which is discharged to the outside. A rotary motion of the sphincter with the spinules would well serve the purpose of shearing the peritrophic membrane. The faecal pellets measure about 0.8 to 1 mm. which is also the length of the rectum.

Following defaecation there is a sudden increase in the frequency of the rectal swallowing. The quantity of water ingested in each intake also increases. When the interval between successive processes of defaecation is short, as in specimen B, this accelerated rate of intake is maintained. When the next defaecation is delayed as in specimen A (more than an hour and a half), this mode tones down. The time required for rendering the intestine completely empty varies a good deal depending on the size and activity of the animal.

Even after a few defaecations, the intestine is turgid having a uniform bulge, the spaces between the columns of faecal matter being filled with water. Here the antiperistaltic movements are at their best with the highest amplitude for the waves. Even after rendering the intestine empty, the spells of anal intake continue for a time after which the fluid is discharged to the outside and the intestine becomes flaccid.

It is obvious that the intake of water bears a relationship to defaecation and it seems natural to assume that the intake of water is primarily to maintain a constant pressure inside the gut. The maintenance of an increased pressure could be demonstrated by inserting the fine point of a needle through the anal aparture into the midgut when the intestine collapses to a certain extent discharging part of the fluid content to the outside. Fox (1952) has disproved the respiratory function attributed earlier to the anal intake of water. He is of opinion that it is of the nature of a natural enema which would mean an increased pressure that stretches the wall of the gut until it contracts.

The oral intake of water could not be studied due to the opaqueness of the cephalothorax. It also shows a rhythm with an average of 14 gulps per minute.

Summary

The anatomy and histology of the foregut, midgut, hindgut, hepatopancreas and midgut caeca have been studied. The stomach exhibits a certain complexity of organisation in comparison with other Caridea. The cardiac and dorsal section of the pyloric stomach show a few important resemblances with *Carataspis*, a penaeid. The absence of a gastric mill has made the extrinisic muscles of the stomach less

developed while the intrinsic muscles are not affected. The working of the stomach and course of food have been studied through the transparent cuticle. The study of the process of secretion and restitution of the gland cells of the digestive diverticulum shows that with the initiation of feeding, the extrusion phase sets in, which lasts for two hours and a half. The restitution phase following this reaches its mode between two hours forty minutes and four hours fifteen minutes. The second extrusion phase is attained five hours after feeding and three hours later the second restitution phase sets in. Certain spherules of cytoplasm and 'vermiform bodies' have been observed inside the midgut and their probable function is discussed. A rectal valve with spinules is described. The frequency, mechanism and probable function of the anal swallowing of water is described.

Acknowledgement

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Asterisks indicate publications which have not been referred to in original.

Fig. 1. Cytoplasmic spherules containing secretory products.
Fig. 2. L.S. through midgut showing ' Vermiform Bodies '.
Fig. 3. L.S. through initial part of hindgut.

J. Mar. biol. Ass. India, 1960, 2 (1): 75-81

POTASSIUM AND CESIUM-137 IN *BIRGUS LATRO* (COCONUT CRAB) MUSCLE COLLECTED AT RONGELAP ATOLL*

By Diptiman Chakravarti and Edward E. Held

Laboratory of Radiation Biology, University of Washington, Seattle, Wash., U.S.A.

Introduction

Rongelap Atoll was contaminated with radioactive fallout resulting from the Bravo test on March 1, 1954, to the extent that it was necessary to evacuate the population of 82 Rongelapese. Some 200 Marshallese returned to Rongelap in June 1957, after the area had been declared safe for human habitation. Since 1954, there have been several surveys to determine the level of radioactive contamination of the biota at Rongelap Atoll (Dunning, 1957). In March 1958, a long-term study of the ecology of the atoll, relative to radioactive contamination, was initiated at the request of the U.S. Atomic Energy Commission, Division of Biology and Medicine.

The objective of this investigation was to determine the radiocesium and stable potassium content in the muscle of *Birgus latro* and to evaluate the relationship between the two, if any, under the existing conditions at Rongelap Atoll.

Birgus latro, the coconut crab, is of particular interest because it is edible and is a land crab known to contain cesium-137 in its muscle tissue. Cesium-137 is also the principal long-lived (27 years half life) fission product found in plants on contaminated islands in the Marshall Islands. There have been conflicting reports in the literature concerning the relationship of potassium to cesium-137 uptake in plants (Auerbach and Crossley, 1958 ; Nishita, *et al.*, 1958 ; Uhler, 1959 ; Nishita *et al.*, 1959). Apparently the uptake of cesium-137 by plants is directly associated with potassium uptake in some cases and not in others.

It was suggested from the results of studies of *Coenobita* at Eniwetok Atoll that seasonal differences in precipitation might influence cesium-137 levels in muscle tissue (Held, 1960) ; the data presented here do not support this suggestion.

Materials and Methods

Samples of *Birgus* muscle were collected from Kabelle, Rongelap, and Eniaetok Islands at Rongelap Atoll during March 1958, August 1958 and March 1959. Two samples were also collected at Utirik Island, Utirik Atoll (Fig. 1) in March 1959. The samples were oven-dried at 98°C and the wet weight to dry weight ratios were determined. For potassium analysis, the samples were wet ashed with concentrated HNO_3 and H_2O_2. The ash was dissolved in a known volume of 1N HNO_3 and

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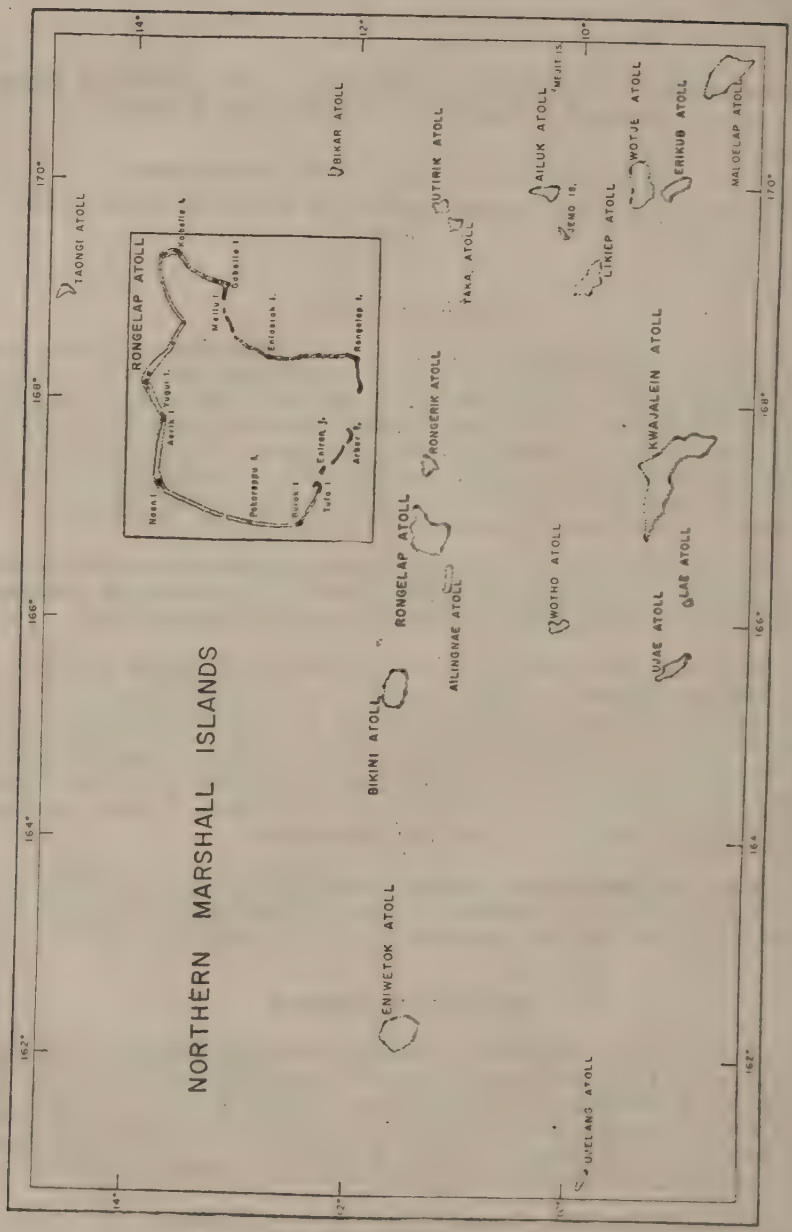
NORTHERN MARSHALL ISLANDS
RONGELAP ATOLL
Rongelap I.
Eniaetok I.
Eniran I.
Arubar I.
Rongerik I.
Aomoetto I.
Taka I.
Aomoetto I.
Aoman I.
Aoman I.
Aoman

the potassium content determined by flame photometry. Details of the method used have been reported by Chakravarti and Joyner (1959).

The levels of cesium-137 were determined by gamma spectroscopy. Five to ten-gram samples of dried muscle were counted. The counting equipment consisted of a three-inch thallium-activated sodium iodide crystal used in conjunction with a 256-channel analyzer with digital print out. The total counts per minute under the photopeak were calculated by summing counts per minute of all channels included in the peak and subtracting the background counts. The counting efficiency for the gamma energy measured was determined by calibrating the instrument with a cesium-137 standard with an error of $\pm$ 10 per cent. The factor used for converting counts per minute to disintegrations per minute was derived from the counting efficiency and from the fraction of the distintegrations giving rise to the gamma radiation being counted. The factor used for cesium-137-barium-137 was 18.0. Detailed descriptions of the counting equipment and standardization procedures used have been given by Lowman *et al.* (1958).

Results and Discussion

The individual values for potassium and cesium-137 in *Birgus* muscle collected at Rongelap Atoll and Utirik Island are presented in Table 1. Average values and their standard deviations for each collection also are given.

The levels of cesium-137 found in individual samples ranged between 731 d/m/g dry weight at Kabelle Island, Rongelap Atoll, and 28 d/m/g dry weight at Utirik Island, Utirik Atoll. The individual variation at any one island was large. Range in values in d/m/g/dry weight at three islands at Rongelap Atoll was as follows : Kabelle 324-731, Eniaetok 369-498, and Rongelap 199-330. However, the average ceisum-137 levels were highest at Kabelle Island, which lies in the northern part of the atoll, and lowest at Rongelap Island, in the southern part. Analysis of variance gave an F value of 23.98 (significant at 1 per cent level), indicating that the difference in cesium-137 values between these two islands is statistically significant. At Eniaetok Island, which lies about half way between Rongelap Island and Kabelle Island, only three samples were obtained, two in March 1958, and one in August 1958. In the former collection the levels were higher than at Kabelle while in the latter collection the level was lower than at Kabelle for the corresponding dates. This apparent inconsistency is probably a result of individual variation. At Utirik Atoll, which lies some 200 miles to the east (Fig. 1), the levels were about one-tenth of the lowest levels at Rongelap.

The gamma dose rates give an indication of the relative levels of radioactive contamination of the different islands. The average gamma dose rates measured three feet above ground in March 1959 at these islands were, Rongelap .031, Eniaetok .051, Kabelle .069 and Utirik .025, expressed as milliroentgens per hour.

Determinations of other radionuclides in *Birgus* muscle indicate that over 90 per cent of the radioactivity is from cesium-137.

For comparison with cesium-137 levels, the average potassium value for each collection is given in Table 1. The average potassium value for all samples was 13.05 mg/g with a standard deviation of 3.66. The range in values was 2.96 to 21.2 mg K/g dry weight, but 83 per cent of the 30 samples analyzed fell in the range of 10 to 15 mg K/g dry weight. The two lowest values of 2.96 and 3.48 mg K/g dry weight

appear to be completely out of line. Repetition of the analysis of these samples gave essentially the same results and no explanation for the disparity is offered.

A significant difference in potassium levels associated either with island or season of collection is not apparent (March falls in the dry season and August in the wet season). Nor is there any correlation between potassium and cesium-137 levels at any one island. In this regard, the data should net be pooled since it has been established that there are differences in cesium-137 levels from island to island. The regression of ceisum-137 on potassium in the crab muscle, as determined in the largest sample from Kabelle Island, indicated no relation between these elements.

Cesium-137 levels have been reported as *cesium units*, micro micro-curies of cesium-137 per gram of potassium (U.S. AEC reports on fallout). This unit is based on metabolic similarity of cesium and potassium and is used to facilitate comparision of different types of materials in a manner similar to the use of the strontium unit adopted by Libby (1956). Anderson, Schuch, Fisher and Langham (1957) have used the gamma ratios of ceisum-137 to potassium-40 in place of the cesium unit. Cesium units for *Birgus* muscle are given in Table 1 for comparison with other published data on fallout given in the same units. However, since the potasium and cesium levels are both highly variable in *Birgus* muscle, there is some doubt as to the usefulness of the unit in this case. For example, the comparatively high value for cesium units of samples from Rongelap Island is due to the exceptionally low potassium content of one of the samples. On the other hand, the high value for the March 1959 collection at Kabelle Island is due to high levels of cesium-137, while the potassium levels are about average.

These differences are not surprising when the following facts are considered. Gross (1959) has reported that *Coenobita*, which has habits similar to those of *Birgus*, obtains blood salts from its food. From work in progress at this Laboratory it is known that *Pandanus* fruit, which form a part of the diet of *Birgus*, vary by as much as a factor of five in cesium-137 content and a factor of four in potassium content and that the range in potassium levels in soils on which *Pandanus* grows at Rongelap is 0.1 to 1.5 milliequivalents per 100 grams. Also, the extremes in the range of gross beta activity in the top inch of soil at a single island can differ by more than a factor of ten. On a basis of the variability in cesium-137 and potassium levels found in the environment alone, one might expect the high degree of variability found in *Birgus*.

An additional factor which may accentuate the condition found in *Birgus* is currently under study at this Laboratory in cooperation with the Department of Botany, University of Washington. The low potassium levels in the soils at Rongelap represent a potassium deficiency for at least some of the plants. Greenhouse experiments in which Rongelap soil was used as well as field trials at Rongelap have demonstrated that potassium fertilization decreases cesium-137 uptake by plants (Walker and Held, 1959). This observation is in agreement with the reported increase in cesium-137 uptake by plants in other soils as the potassium concentration in the soil is reduced by prolonged cropping (Nishita *et al.*, 1958 and 1959). It appears possible that if a surplus of potassium were present in the soils at Rongelap, potassium levels in *Birgus* muscle would be more uniform and cesium-137 levels lower.

The simplest system studied at Rongelap with respect to cesium-137 and potassium was the soil. Cesium-137 and potassium in rain water which had percolated through undisturbed soils were found to be present in approximately

proportional amounts under changing conditions of precipitation and fertilization (Cole *et al.*, 1959). However, at the second or higher trophic level, represented by *Birgus*, if any such relationship exists between the uptake of cesium and potassium, it is masked by several unknown variables in the ecosystem.

Summary

Radiocesium and stable potassium levels were determined in samples of muscle tissue of *Birgus latro*, the coconut crab, collected at Rongelap Atoll, Marshall Islands, during March and August, 1958, and March 1959, and at Utirik Atoll in March 1959. Levels of cesium-137 ranged between 731 d/m/g dry weight at Kabelle Island, Rongelap Atoll, and 28 d/m/g dry weight at Utirik Island, Utirik Atoll. The average potassium value for all samples was 13.05 mg/g dry weight with a standard deviation of 3.66. No significant correlation between cesium-137 and potassium levels was found. There was no significant difference in the average levels of cesium-137 in crabs collected at different times at the same island.

Table I

Potassium and cesium-137 in *Birgus latro* (coconut crab) muscle collected at Rongelap Atoll and Utirik Island, Utirik Atoll

Kabelle Island

	Sample No.	Cesium-137 d/m/g dry weight	Potassium mg/g dry weight	Cesium Unit $\mu\mu$c Cs^{137} /g K	Wet/dry ratio
March 1958 (dry season)	34	604	13.28	20489	4.212
	35	426	10.32	18594	3.794
	36	349	11.40	13789	3.591
	37	410	17.68	10447	4.082
	38	437	13.04	15092	3.743
		Av. = 445 S.D. = 95	Av. = 13.14 S.D. = 2.81	Av. = 15682 S.D. = 3966	Av. = 3.884 S.D. = 0.252
August 1958 (wet season)	7	661	17.25	17258	4.930
	8	438	14.68	13440	3.480
	9	454	11.99	17056	3.807
	10	325	15.03	9741	4.308
	11	650	11.92	24564	3.946
	12	324	13.87	10519	3.660
		Av. = 475 S.D. = 150	Av. = 14.12 S.D. = 2.02	Av. = 15430 S.D. = 5474	Av. = 4.022 S.D. = 0.424
March 1959 (dry season)	1	524	12.72	18546	4.470
	2	619	12.64	22065	4.330
	3	731	11.76	27993	4.840
	5	645	12.00	24217	5.140
		Av. = 630 S.D. = 85	Av. = 12.28 S.D. = 0.47	Av. = 23205 S.D. = 3956	Av. = 4.695 S.D. = 0.366

	Sample No.	Cesium-137 d/m/g dry weight	Potassium mg/g dry weight	Cesium Unit $\mu\mu$c Cs^{137} /g K	Wet/dry ratio
Rongelap Island					
March 1958 (dry season)	84	199	12.18	7356	3.895
	85	219	15.40	6403	4.243
	86	276	19.20	6474	4.419
	87	202	2.96	30743	3.693
	88	261	14.72	7989	5.130
		A.v. = 231 S.D. = 35	Av. = 12.89 S.D. = 6.09	Av. = 11793 S.D. = 10614	Av. = 4.276 S.D. = 0.556
August 1958 (wet season)	2	228	12.71	8080	5.254
	3	206	11.77	7884	3.784
	4	324	9.96	14648	4.238
	5	330	15.35	9681	4.373
	6	254	13.44	8512	4.144
		Av. = 268 S.D. = 56	Av. = 12.65 S.D. = 2.00	Av. = 9761 S.D. = 2819	Av. = 4.360 S.D. = 0.543
Eniaetok Island					
March 1958 (dry season)	61	498	14.08	15930	5.000
	62	498	21.18	10590	4.356
		Av. = 498 S.D. = 00	Av. = 17.63 S.D. = 5.02	Av. = 13260 S.D. = 3776	Av. = 4.678 S.D. = 0.455
August 1958 (wet season)	1	369	14.01	11863	4.764
Utirik Island					
March 1959 (dry season)	4	31	3.48	4023	4.321
	6	28	11.64	1102	4.238
		Av. = 29.5 S.D. = 4.5	Av. = 7.56 S.D. = 5.77	Av. = 2562 S.D. = 2065	Av. = 4.280 S.D. = 0.057

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ON NEW RECORDS OF FIVE SPECIES OF PENAEINAE (*DECAPODA MACRURA : PENAEIDAE*) ON THE WEST COAST* OF INDIA

By M. M. KUNJU

Central Marine Fisheries Research Sub-station, Bombay-1

WHILE examining the composition of the prawn landings in the various fishing centres of Bombay the writer has come across five species of penaeid prawns which are new records in Bombay and the west coast of India. They constitute a considerable portion of the prawn catch in Bombay, one of them viz. *Parapenaeopsis hardwickii* being a major species of commercial value.

They are dealt with below in the order of abundance :

Parapenaeopsis hardwickii (Miers)

Alcock (1906) designated this prawn as a variety of *Parapenaeopsis sculptilis* Heller. By comparative analysis of the morphological features Burkenroad (1934 *a*) established it as a distinct species with pronounced specific characters, and he has since been followed by all workers such as Kubo (1949) and Dall (1957).

The adults of *P. hardwickii* are much smaller than *P. sculptilis* Heller; females seem to attain maturity at a minimum length of about 70 mm. and males at about 50 mm. In the field the species can be distinguished from *P. sculptilis* by the absence of the median carination of the first two pleonic terga, the distomedian lobes of the petasma not extending wing-like beyond the lateral cornua, the absence of median tuft of setae on the posterior plate of thelycum and the presence of three pairs of small but recognisable spines on the lateral margins of the telson. The two sexes are dimorphic, males being considerably smaller in size than females. The rostrum in all the mature males is devoid of the unarmed styliform portion. Burkenroad (1934 *a*) has remarked in the case of male *P. sculptilis* that the shorter rostrum is characteristic of ' an adult instar ultimately attained by all males'. Since the male rostrum is less robust it is likely to get broken more easily (Dall, 1957). The immature males have the styliform portion of the rostrum unduly elongated.

The species appears to be well distributed along the coast of Bombay, forming one of the major species of fishery value. They occur in large numbers at Dahanu, Satpati, Arnala, Versova and Sassoon Docks. Stray individuals were picked up from Alibag and Janjira-Murud in the month of May, 1959.

Alcock recorded *P.sculptilis* var. *hardwickii* from Orissa, Ganjam, Madras and Pondicherry.

Atypopenaeus compressipes (Henderson)

This is a small penaeid prawn, the vast majority of the adult females falling within a length range of 40 to 50 mm. and males within 35 to 40 mm. In the ' dol '

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nets (fixed bag nets) operating at about a depth of 6 to 7 fathoms off Sassoon Docks at the entrance to the Bombay harbour and at depths of 6 to 15 fathoms off Versova (Bombay) these prawns are caught in large numbers throughout the year. Members of the genus including *A. compressipes* are regarded as rare in occurrence by Kubo (1949) and Dall (1957). Alcock (1906) recorded only a single male 1 $\frac{3}{8}$" long, obtained off Madras at a depth of 12 fathoms.

Parapenaeopsis acclivirostris Alcock

The species is found in small numbers in the prawn landings at Sassoon Docks. In the month of March, 1960 nineteen individuals were collected from the ' dol ' and Otter trawl catches made from a depth of 6 to 20 fathoms. Among the Indian Penaeinae it is remarkable in the absence of the isolated epigastric tooth on the carapace, and therefore can easily be identified. Alcock's material consisted of 34 females collected from Madras, Ganjam, Vizagapatam and the Palk Strait. The male of the species is recorded now for the first time and an account of it is being published separately. As in the case of *P. hardwickii* the males are considerably smaller than females.

Metapenaeopsis novae-guineae (Haswell)

It is a medium sized penaeid growing to about 90 mm. in length and is represented in the ' dol ' net catches of Bombay in fairly large numbers, particularly in the months of October and November.*

It is synonymous with *Metapenaeus stridulans* Alcock. Burkenroad (1934 *a* and *b*) redefined the genera *Metapenaeus* of Wood-Mason and Alcock (1891) and *Metapenaeopsis* of Bouvier (1905) and proposed the sub-genus *Metapenaeopsis* to separate out species with an asymmetrical petasma from those with a symmetrical one. Subsequently Kubo (1949) elevated the sub-genus to generic rank. *Metapenaeus stridulans* Alcock has been brought under *Metapenaeopsis* by various authors, and the specific synonymy was first stated by Schmitt (1926). The material collected from Bombay conforms to the description and figures of *Metapenaeopsis novae-guineae* given by Kubo (1949) and Dall (1957).

Alcock recorded his species from Orissa, Ganjam, Andamans, Vizagapatam, Madras and the Palk-Strait.

Trachypenaeus curvirostris (Stimpson)

The species is not as common as the above four, a few individuals only having been collected from a ' dol ' net catch from off Sassoon Docks in November, 1959. A closely similar species viz. *T. asper* Alcock has been reported from the Ganjam coast and the Andamans.

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*Its occurrence has been noticed by Dr. (Miss) F. S. Shaikhmahmud (Central Marine Fisheries Research Sub-station, Bombay) also.

Metapenaeopsis novae-guineae and *Trachypeneus curvirostris* are normally deep sea forms, occurring beyond the 20 fathom line ; but both of them have been collected in Bombay from the ' dol ' net catches of 6 to 15 fathoms.

My thanks are due to Shri M. Krishna Menon, Research Officer (Prawns), Central Marine Fisheries Research Sub-station, Ernakulam for his valuable comments in the preparation of the note.

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J. Mar. biol. Ass. India, 1960, **2** (1): 85-88

ON THE SNAKE MACKEREL, *GEMPYLUS SERPENS* CUVIER FROM THE LACCADIVE SEA

By S. Jones

Central Marine Fisheries Research Station, Mandapam Camp

Introduction

During the third cruise of R. V. KALAVA in the Laccadive Sea (Jones 1959) two specimens of *Gempylus serpens* Cuvier, measuring 580 mm. and 434 mm. in standard length were collected by me from Station No. 449 (Lat. 10°.39′ N. Long. 72°.42′ E) on 29-4-1959. The vessel stopped at this Station at 20.00 hrs. and the fish came the ship's side evidently attracted by the search light. The larger of the two (Plate I, fig. 1) was seen at about 20.30 hrs. and the second specimen about an hour later. The sea in this area is about 2200 metres deep.

G. serpens is a bathypelagic form known from a number of places in the tropical regions of the Atlantic and Pacific Oceans (Heyerdahl 1950, Herre 1953, Matsubara and Iwaii 1952 and Munro 1958). Except for a solitary specimen from East London, South Africa (Bernard 1927), it has not been recorded so far from the Indian Ocean. Its distribution in the Indo-Pacific is given in Plate II.

Gempylus serpens Cuvier

Gempylus serpens Cuvier, 1829. *Regne Animal*, ed. 2, 2 : 200.

A description of the two specimens from the Laccadive Sea is given below.

Meristic Counts :

D_1. XXVIII ; D_2. iv. 9–6 (19) ; P_1. 14 ; P_2. I. 4 : A I-II. 9-10+7 (18-19) : C. i, 15, i, gill rakers 1+1+4 -5.

Description :

Dorsal profile more or less straight from snout to origin of second dorsal from whence it gradually slopes to base of caudal. Similarly ventral profile slopes from origin of anal towards base of caudal.

Head 5.13 to 5.69 ; first predorsal distance 5.85 to 6.07 ; base of first dorsal 1.7 to 1.79 ; second predorsal distance 1.3 ; base of second dorsal 12.4 to 12.76 ; base of second dorsal with finlets 4.61 to 4.66 ; snout to pectoral 4.93 to 5.12 ; snout to pelvic 4.42 to 4.46 ; snout to vent 1.45 to 1.57 ; snout to anal 1.3 ; pelvic origin to vent 2.2 ; pelvic origin to anal 1.87 to 1.94 ; base of anal 12.0 to 12.9 ; base of anal with finlets 4.4 to 4.6 ; length of first dorsal spine 23.2 to 28.9 ; length of second dorsal 16.07 to 18.71 ; longest dorsal finlet 33.4 to 36.16; length of pectoral fin 9.4 to 10.3 ; length of pelvic 62.0 to 72.0 ; length of anal 19.3 to 20.6 ; longest anal finlet 35.1 to 36.1 ; height of body 15.4 to 16.1 ; width of body 28.0 to 29.0 ; height of caudal peduncle

37.7 to 38.6 ; width of caudal peduncle 69.8 to 72.3; and length of caudal peduncle 23.8 to 31 in standard length. Snout 2.08 to 2.18 ; eye 6.1 to 6.3 ; interorbital distance 6.8 ; height of head at occiput 2.79 to 3.1 ; width of head 4.3 to 4.5 ; length of pectoral 1.84 to 2.02 and length of pelvic 12.14 to 14.12 in head length. Least height of caudal peduncle contained 1.2 to 1.62 in its length.

Lateral line double, commencing just above upper angle of opercle. Upper lateral line running parallel to base of first dorsal upto about origin of second dorsal from where it abruptuly disappears. Lower lateral line gently curves down above base of pectoral from where it runs in a straight line along midlateral part of body to about base of caudal fin.

Eyes conspicuously large. Maxilla extends to below vertical from middle of eye. Posterior nasal openings situated nearest to eye than to tip of snout.

Outer margin of dorsal fin more or less straight. Pectoral shorter than head, not extending beyond vertical below seventh dorsal spine. Pelvics minute with the first ray slightly elongate, origin slightly behind that of pectorals. Anal origin slightly behind that of second dorsal ; caudal deeply forked.

Teeth are well developed and are represented as follows in the two specimens.

	Specimen A [1] (580 mm.)		Specimen B [2] (434 mm.)	
	Right	Left	Right	Left
Upper Jaw	18+11 [3]	15+11	12+1	12+11
Lower Jaw	18	15	16	16

[1] Male ; [2] Sex indeterminate ; [3] Caniniform teeth.

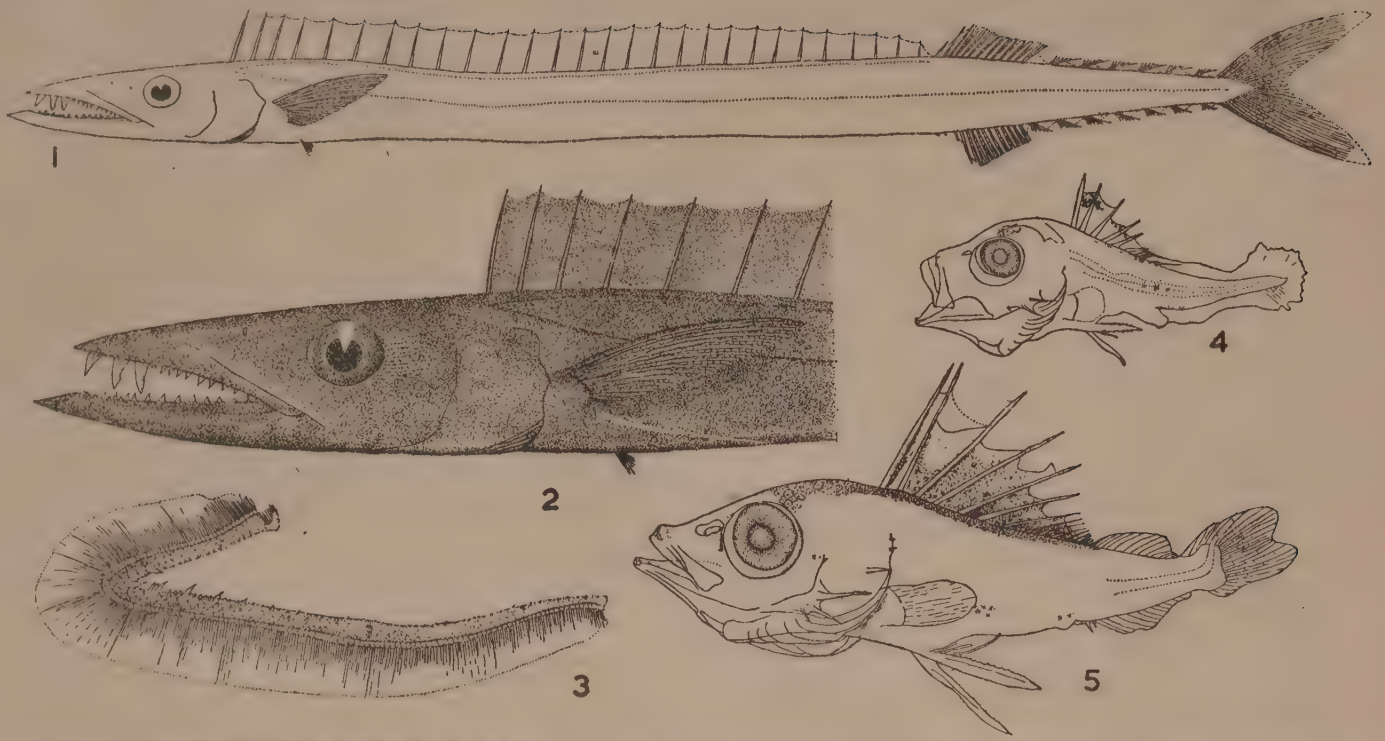
On preservation, body dorsally, sooty black, greyish along abdomen ; pectorals, caudal and interspinous membrane of first dorsal dark greyish. Head superiorly same as body colour ; lighter patches on maxilla, mandibles and operculum.

Incidentally it may be mentioned here that Tucker (1956) gives the dorsal fin ray count of *G. serpens* as spines 29 to 32 and soft rays 18. The same author gives the ventral count as 53.

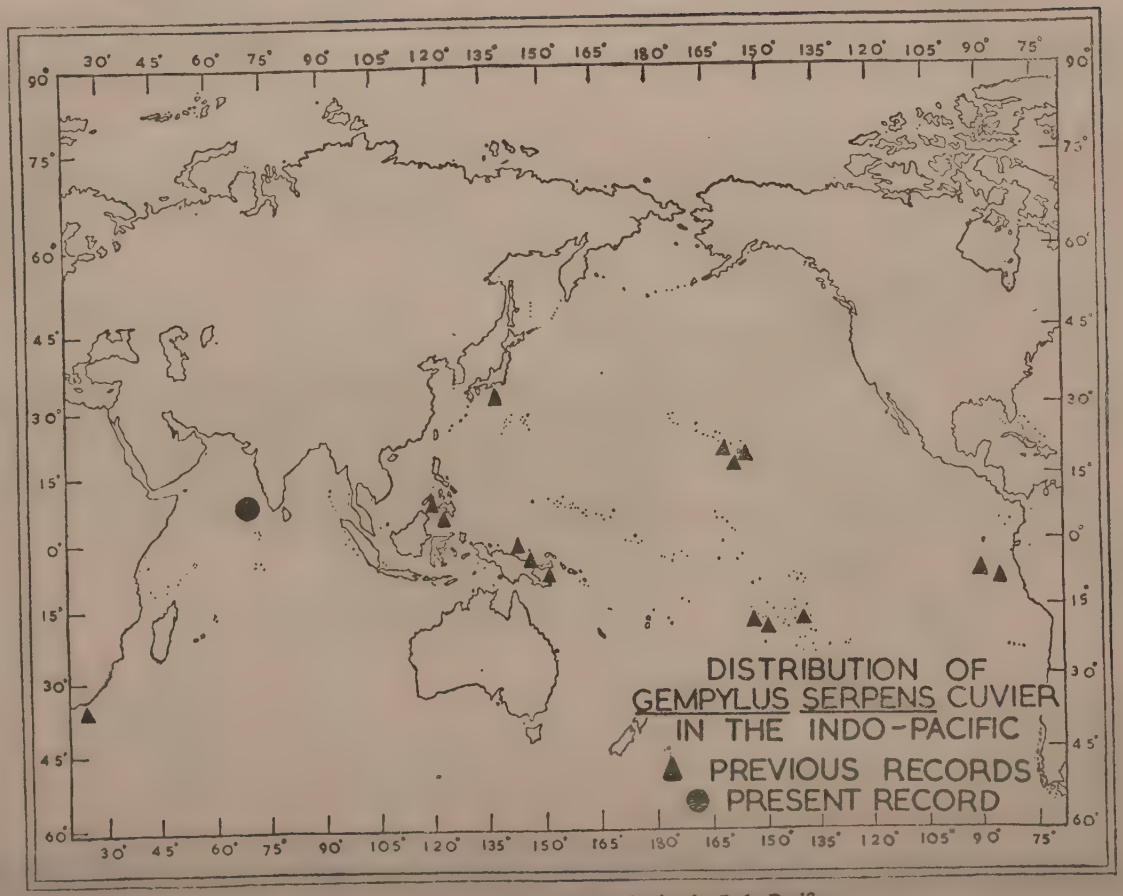
G. serpens is a carnivorous fish and possesses very prominant caniniform teeth (Plate I, fig. 2). The first gill arch is shown in Plate I, fig. 3. This species grows to a length of about one metre.

Larvae of *Gempylus serpens* Cuvier

A number of larval stages which were identified as belonging to this species have been collected from the Laccadive Sea during the cruises of R. V. KALAVA and two specimens measuring 4.91 and 8.28 mm. are figured (Plate I, figs. 4 & 5). The larvae of *G. serpens* have been found in the collections of the Dana Expedition from



I. *Gempylus serpens* Cuvier from the Laccadive Sea. 1. Outline figure of the 580 mm. specimen from KALAVA Station No. 449 ; 2. Head of the above ; 3. The first gill arch ; 4. 4.91 mm. larva from KALAVA Station No. 218 ; 5. 8.28 mm. larva from KALAVA Station No. 448. (Figs. 1-3 by K. L. K. Kesavan and 4 & 5 by Egbert Dawson).



II. Distribution of *Gempylus serpens* Cuvier in the Indo-Pacific.

the Indian Ocean and these along with those from the Laccadive Sea will be described elsewhere. The list of the KALAVA stations from where larval *G. serpens* have been collected are given below.

TABLE I

Details of larval *Gempylus serpens* collected from the Laccadive Sea.*

Date	Time	Station	Lat.	Long.	No. of specimens	Remarks
21-2-'58	08.30-08.35	209	73°08′	8°22′	4	Minicoy, outside the reef
24-2-'58	18.45-21.50	213	72°42′	9°43′	2	
28-2-'58	15.27-17.50	218	74°10′	10°03′	7	One specimen drawn (Plate I fig. 4)
9-4-'59	05.45-06.50	432	72°58′	10°38′	2	
29-4-'59	13.40-15.05	448	72°26′	10°46′	1	Drawn (Plate 1 fig. 5)
29-4-'59	19.50	449	72°42′	10°39′	1	
30-4-'59	11.15-11.38	453	73°40′	10°04′	3	

*In addition to those given in the table above there are 4 specimens collected on 8-11-1956 by Mr. M. Kumaran from about 60 miles north of Minicoy while proceeding to the Island in a sailing boat.

DISTRIBUTION

Circumtropical. Most of the records from the Atlantic Ocean are from the Carribbean Sea. It has been recorded from a number of places in the Pacific and from East London, S. Africa in the Indian Ocean. From the present record which is the first from the Central part of the Indian Ocean and from the distribution of the larval specimens it appears that the fish has a fairly wide distribution in the Indian Ocean.

ACKNOWLEDGEMENT

My sincere thanks are due to the Indo-Norwegian Project for all the facilities given and courtesies shown during my cruises on board R. V. KALAVA. I am grateful to Dr. E. G. Silas for the help rendered in preparing the description.

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ON A LITTLE KNOWN INDIAN COBITID FISH, *ENOBARBICHTHYS MACULATUS* (DAY) *

By E. G. Silas

Central Marine Fisheries Research Station, Mandapam Camp

Introduction

In 1867 Dr. Francis Day described a small loach from Madras as *Platacanthus maculatus*, with a characteristic long dorsal fin composed of 30 rays. However, the type of the genus *Platacanthus* Day (1865), namely, *P. agrensis* Day is a synonym of *Lepidocephalus thermalis* (Valenciennes), which is characterised by a very short dorsal fin with only 9 rays. This naturally restricted *Platacanthus* Day to the synonymy of *Lepidocephalus* Bleeker and hence Day (1870) proposed the generic name *Jerdonia* to accommodate the second species *Platacanthus maculatus*, defining the genus as ' Body elongated. Barbels eight, one rostral, two maxillary and one mandibular pairs. A free bifurcated suborbital spine. Dorsal fin elongated (thirty rays). Internal pectoral rays osseous. Origin of anal slightly posterior to the termination of the dorsal.'

Unfortunately, the name *Jerdonia* is preoccupied in Malacology (Blandford, 1861), and in Ornithology (Hume, 1870), a situation of which Day himself was probably aware of, as in his monographic series on Indian Cyprinidae (Day, 1872 : 179) in a foot-note under the genus *Jerdonia* there appears an editorial comment that ' This name has been also applied in concology and Ornithology.' Hence, in accordance with the Rules of Zoological Nomenclature, Whitley (1931) proposed the name *Enobarbichthys* to replace *Jerdonia* Day, with *Platacanthus maculatus* Day as the type, and thus far the genus is monotypic.

Besides Day's account of this loach based on a single specimen, nothing more is known about it. Hence it is felt desirable to record here some additional data I was able to gather by re-examining the holotype in the collection of the British Museum (Natural History) in September 1956.

Enobarbichthys maculatus (Day)

Platacanthus maculatus Day, 1867. *Proc. Zool. Soc. London*, 941-942 (Type locality : Madras, India).

Jerdonia maculata Day, 1870. *Proc. Zool. Soc. London*, 700 (1871) (New genus proposed to accommodate *P. maculatus* Day) ; 1872. *Journ. Asiat. Soc. Bengal*, 42(2) : 179 (Description) ; Beaven, 1877. *Handbook Freshw. Fish.*

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India, 113 (Diagnosis after Day) : Day, 1878. *Fish. India*, 611, pl. cliv, fig. 6 ; 1889, *Faun. Brit. India, Fish*, 1 : 223, fig. 82.

Enobarbichthys maculatus Whitely, 1931. *Rec. Aust. Mus.*, 18 : 107 (Nomenclatorial change only).

Material :

Holotype—British Museum (Nat. Hist.) No. 68. 10. 27. 36 labelled as collected by Dr. Day from Madras.

Meristic Counts :

D. iii, 28 ; P_1. i, 5, I (Fused rays) ; P_2. i, 7 ; A. iii, 5 ; C. i, 21, i. My counts of the holotype slightly differ from those made by Day, which are : D. iii, 27 ; P_1. 5, I ; P_2.8 ; A. iii, 6 ; C. 21.

Measurements :

TABLE I

Characters	Millimetres	Thousandths of standard length
Standard length	38.00	
Length of head	8.00	 210
Width of head	3.50	 92
Diameter of eye	2.00	 53
Length of snout	3.00	 79
Inter-orbital distance	1.75	 46
Inter-nasal distance	1.25	 33
Height of head at occiput	5.50	 144
Length of suborbital spine	1.00	 26
Greatest height of body	7.00	 184
Width of body	3.00	 79
Length of caudal peduncle	3.50	 92
Least height of caudal peduncle	5.00	 131
Tip of snout to origin of dorsal	17.00	 447
Height of dorsal	6.75	 178
Length of base of dorsal	13.25	 349
Tip of snout to origin of pectoral	9.00	 237
Tip of snout to origin of pelvic	21.00	 553
Tip of snout to origin of anal	30.00	 789
Origin of pectoral to that of pelvic	11.75	 309
Origin of pelvic to that of anal	9.50	 250
Height of anal	6.00	 158
Base of anal	4.50	 118
Length of pectoral	7.50	 197
Length of pelvic	6.50	 171
Length of caudal	10.00	 263

Colouration :

The colour of this specimen was given by Day (1867) as being ' Greyish, becoming dirty white below the centre of the body. A dark line passes from the eye to the centre of the tail. Along its first half are six black spots, whilst the whole extent of the back is irregularly lineated. Fins yellowish. Dorsal with four darkish bands

along it. Caudal with three bands and a black margin. A black mark at the base of the tail, with a smaller one above and another below it.' Much of this pretty pattern has disappeared in the specimen due to long preservation. However, a conspicuous black spot similar to the one seen at the upper part of the base of the caudal fin in *Lepidocephalus thermalis* is present in the specimen (Fig. 1). The lateral band from the posterior margin of the eye to the base of the caudal fin is faintly discernible.

Scale Structure:

But for the remarks that ' scale minute, covering body ' (Day, 1867), and ' Scales small, but distinct ' (Day, 1872), nothing more is known about them. I find that as in *Lepidocephalus* the scales are non-deciduous. I have been able to examine a few typical scales of this specimen from the side of the body below the insertion of the dorsal fin and above the mid lateral line and the details are summarised in Table III, and two of the scales are figured (Plate, figs. A & B). Distinctive features are the shape which is oblong, markedly longer than broad ; the basal position of the nucleus and the more numerous complete and incomplete radii. A scale from another part of the body just above the middle of the pectoral (size 0.628 × 0.513 mm.) has an unusually large number of radii, the counts being 22 complete and 2 incomplete basal radii ; 21 complete and 3 incomplete apical radii ; 8 and 3, and 7 and 3 complete and incomplete lateral radii on either side. However, the number of basal and apical circuli remains less variable, the numbers being 9 and 22 respectively.

The shape and sculpturing of the scales of *E. maculatus* show affinities to that of *Lepidocephalus thermalis*, but distinctly differ from the condition seen in the cobitid genera *Botia*, *Noemacheilus*, etc. As such, the scales from an identical area of a specimen of *L. thermalis*. 38 mm. in standard length were also examined and to facilitate comparison, the details of 9 such scales taken at random from the selected area are given in Table III, and one figured (Plate, fig. C). The scales of *E.maculatus* are larger and relatively longer than broad when compared to those of *L.thermalis* as will be seen from Table II.

TABLE II

Species	No. of scales	Length (mm.)		Width (mm.)	
		Range	Average	Range	Average
Enobarbichthys maculatus (Day)	6	0.571-0.742	0.637	0.342-0.399	0.380
Lepidocephalus thermalis (Valenciennes)	9	0.456-0.571	0.526	0.342-0.399	0.380

The nucleus is basal and well defined in *L.thermalis*, and in addition it has relatively fewer radii, especially in the apical region and also fewer basal and apical circuli, while the number of incomplete lateral radii are greater than in *E. maculatus*.

TABLE III

Scales No. (Length × Width) in mm.	Basal Radii		Apical Radii		Lateral Radii				Basal Circuli (Maximum Number)	Apical Circuli (Maximum Number)
					Left		Right			
	Complete	Incomplete	Complete	Incomplete	Complete	Incomplete	Complete	Incomplete		
1. (0.571 × 0.342)	9	4	13	1	4	4	3	2	9	21
2. (0.571 × 0.399)	12	2	13	2	4	2	4	2	10	22
3. (0.685 × 0.399)	9	2	14	1	5	2	4	2	10	22
4. (0.685 × 0.399)	14	—	15	—	5	—	4	2	10	21
5. (0.742 × 0.399)	10	2	14	—	5	3	6	2	10	25
6. (0.571 × 0.342)	10	2	12	4	5	1	5	2	9	22
Range and (Average) *Enobarbichthys maculatus* (Day). (Standard Length 38 mm.)	9—14 (10.6)	2—4 (2.4)	12—15 (13.01)	1—4 (2)	4—5 (4.63)	1—4 (2.4)	3—6 (4.33)	2 (2)	9—10 (9.66)	21—25 (22.16)
Range and (Average) For 9 scales of *Lepidocephalus thermalis* (val.) (Standard Length 38 mm.)	9—12 (10.1)	2 (2)	8—11 (9.5)	1—3 (2)	2—5 (3.33)	2—4 (3.11)	2—5 (3.77)	1—5 (3.0)	8—10 8.66)	18—20 19.1)

[1] Scales of both the species were taken from an identical place below the insertion of the dorsal and above the mid-lateral line.

Enobarbichthys maculatus (Day). Lateral view of holotype 38 mm. in standard length. x2.

Habits:

The observations of Day (1867 : 942) on some habits of this interesting loach are worth reiterating. He remarks that 'This pretty loach was kept upwards of a month in a vase of water. When at rest it usually remained on the sand or rock work supported by its two pectoral and anal fins, its abdomen not touching the ground. When frightened it burrowed under the sand with great rapidity. It consumed animal or vegetable food indiferrently and grew considerably while in confinement.' Whether the fused inner pectoral rays has anything to do with sexual dimorphism as in *Lepidocephalus thermalis*, in which the male has a similar development, is not known. If this is not the case it may represent a functional adaptation of the animal to help it to rapidly burrow under the sand. But if so, it is enigmatic why the inner and not the outer pectoral rays should show such modifications. The stance it takes while at rest is reminiscent of certain burrow dwelling gobies which remain at the entrance of burrows in a slanting position supported by the tips of the pectoral and anal, the rays of the latter fin also being generally elongate as in *E. maculatus* in which when adpressed it reaches the base of the caudal. It is interesting that there is no mention in Day's above cited reference to this fish normally ever showing restlessness and ascending to the surface of the water to gulp in atmospheric air, a conspicuous behaviour of species of *Lepidocephalus*.

Affinities:

In the possession of the bifurcate suborbital spine *Enobarbichthys* differs from the cobitid genera *Noemacheilus*, *Aborichthys*, *Misgurnus*, etc. However, this character is shared by several other genera including *Botia*, *Apua*, *Acanthopsis*, *Acanthopthalmus*, and *Lepidocephalus*, but the usually long dorsal fin of *Enobarbichthys* with 31 rays easily sets it apart from all these genera. As already mentioned, the scale characteristics show divergence from that of *Botia*, as given by Hora (1922), and also that of *Adiposa*, as given by Hora and Annandale (1920), while they appear to be more akin to that of *Lepidocephalus*. The two known species of the genus *Vaillantella* Fowler, namely *V. euepipterus* (Vaillant), and *V. maassi* Weber & de Beaufort from Borneo and Sumatra respectively are characterised by over 60 dorsal rays and unlike *Enobarbichthys*, the suborbital spine is also absent. In short, external morphological characters indicate *Enobarbichthys* to be more allied to *Lepidocephalus* than to any other cobited genus. Efforts should be made to rediscover this rare fish which is thus far known only from a single specimen.

In conclusion it may be mentioned that in the classification of the Cobitidae, the differentiation of species in certain genera have always confronted the taxonomist

with several problems. It would appear that wherever possible, the study of the scale characteristics of such species may aid in taxonomic discrimination.

Acknowledgement

I am extremely grateful to Dr. Ethelwyn Trewavas of the British Museum (Natural History) for giving me all facilities to study the type material of Indian fishes in the British Museum collections during my two visits to that Institution in 1955-'56. I am also thankful to Dr. S. Jones, Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp, for giving me facilities to work in this Institution and to Mr. K. G. Nambiar for taking the photomicrographs of the fish scales.

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A-B.—Scales from the side of the body below the insertion of the dorsal fin and above the midlateral line of the holotype of *Enobarbichthys maculatus* (Day); C. Scale from an identical position of *Lepidocephalus thermalis* (Valenciennes), 38 mm. in standard length.

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A CASE OF HERMAPHRODITISM AND SOME OTHER GONADAL ABNORMALITIES IN THE SKIPJACK *KATSUWONUS PELAMIS** (LINNAEUS)

By G. Raju

Central Marine Fisheries Research Unit, Tuticorin

In the course of the examination of more than 2300 gonads of *Katsuwonus pelamis* (Linnaeus) for the study of the spawning habits of this fish, from the Laccadive Sea at Minicoy, I came across three abnormal gonads including a hermaphrodite one. As this is the first record of abnormal gonads of tuna from Indian waters, it has been described in this present note.

The normal gonads of the skipjack (Fig. 1) are paired and elongate organs with the left lobe usually being slightly larger than the right and both are suspended from

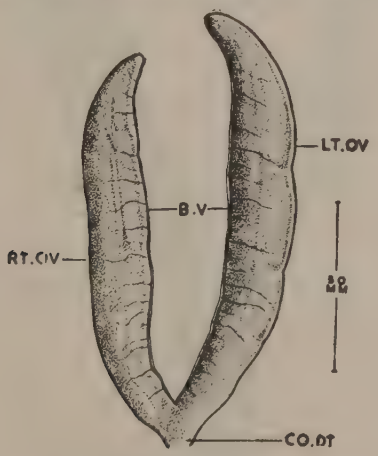

Fig. 1. Normal ovary of 415 mm. Standard length specimen.
B.V. Blood vessels, CO.DT. common duct, LT.OV. Left ovary, RT.OV. Right ovary.

the dorsal wall of the body cavity by a fold of the peritoneum. They are free distally but proximally they unite to form a common duct opening into the cloaca. In the female the posterior part of the ovary itself functions as the duct whereas in the male there is a slender duct running along the entire length of the mid-ventral side of each testis.

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Hermaphrodite Gonad
(Fig. 2)

The only instance of hermaphroditism recorded from among the various tunas appear to be that of Nakamura (1935) who has also noticed this in *Katsuwonus pelamis* from the Pacific Ocean. In the hermaphrodite specimen from Minicoy which does not show any apparent changes in other body characters, the details are as follows :

The left gonad consists of a lower long, narrow, dorsoventrally compressed white testicular region and an upper somewhat broad, oval, yellow ovarian region, elliptical in cross-section. The right gonad consisting of the lower white testicular region is convex dorsally and grooved ventrally whereas the ovarian region which is somewhat similar to the left one is more rounded in cross-section. For a comparison the measurements of the body, the testicular and ovarian regions of the hermaphrodite animal, are given along with that of two normal individuals (male and female) of about the same size group (Table IA).

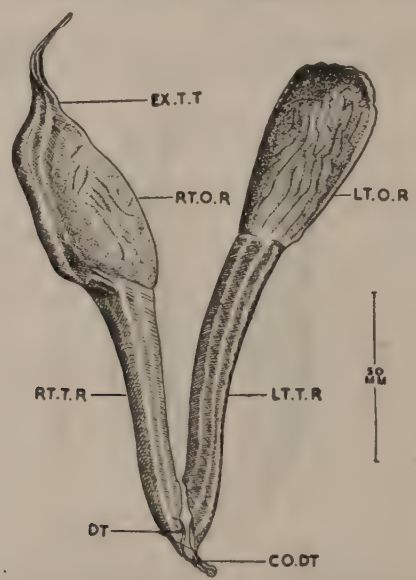

Fig. 2. Hermaphrodite Gonad.

Shows the relative position, shape and size of the different regions.
CO.DT. Common duct, DT. Ducts of the two sides emerging from the testes, Ex. T.T. Extensions of the testicular tissue, LT.O.R. Left ovarian region, LT.T.R. Left testicular region, RT.O.R. Right ovarian region, RT.T.R. Right testicular region.

It is interesting to note that in the left gonad while the upper and lower parts are exclusively of ovarian and testicular tissues respectively, in the right, there is an extension of thin layer of testicular tissue over the ovarian region which after spreading dorso-ventrally is prolonged above as a tapering horn-like structure (Fig. 2).

The microscopical examination of the ovary reveals the presence of translucent yellow ripe ova with a conspicuous golden yellow oil globule. They vary from 0.627 to 0.809 mm. in diameter with a mode at 0.726 mm. and lie freely in the lumen of the ovary while the opaque yolky maturing ova (0.182 to 0.612 mm.) mixed with transparent immature ova are found attached to the follicles lining the ovary.

The specimen was collected during the normal spawning period of this species and its size of 417 mm. (Standard length) perhaps indicates its attaining maturity for the first time. Though the ovarian regions are fully ripe the testicular regions appear to be just maturing with the right lobe somewhat more advanced in maturity than its left counterpart.

This rare phenomenon in fishes is of interest as hermaphroditism as a 'teratological' condition is recorded only for a few groups of fishes and notable recent contributions on the subject are by Prabhu and Antony Raja (1959), Reed (1954), Lagler and Mary (1951), Chacko & Krishnamorthy (1949), Dence (1938), Schultz (1931), and Bishop (1920). The literature regarding functional or true hermaphroditism is reviewed by Lavenda Nathan (1949).

Ovary with the Divided Right Lobe

(Fig. 3)

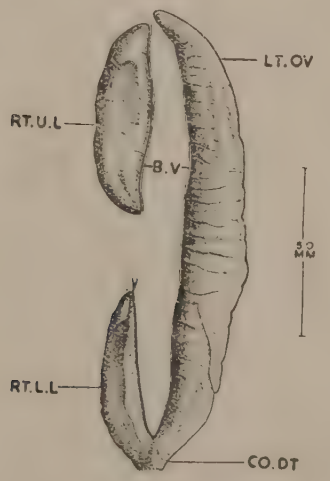

Fig. 3. Ovary with Divided Right Lobe.

B.V. Blood vessels, CO.DT. common duct, LT.OV. Left ovary, RT.L.L. Right lower lobe, RT.U.L. Right upper lobe.

The left ovary is normal in appearance. But in the right side there are two short lobes ; an upper and a lower one 24 mm. apart from each other. The upper one is completely cut off without any connection with its fellow of either the opposite side or its own side, excepting that they are all suspended by the same peritoneal

TABLE I A

Comparison of the Different parts of the abnormal Gonads with those of the normal specimens of the same size range

Description of the specimen	Measurements of the body		Measurements of testis (mm).							Measurements of ovaries (mm.)								Date of collection
	Standard length (mm)	Weight (kg)	Length of		Breadth of		Maturity of		Diameter of the duct	Length of		Breadth of		Maturity of		Diameter of the duct	Diameter of the most mature group of ova	
			Right lobe	Left lobe	Right lobe	Left lobe	Right lobe	Left lobe		Right lobe	Left lobe	Right lobe	Left lobe	Right lobe	Left lobe			
Herma-phrodite	417	2.04	86	94	16	14	Ripen-ing Stage V	Matur-ing Stage III	1.7	59	57	30	28	Ripe ready for spawn-ing Stage VI	Simi-lar to right		0.627 to 0.809	22nd Feb. 1959
Normal male	418	1.70	129	132	19	21	Mature Stage IV	Similar to right	1.6	—	—	—	—	—	—	—	—	—
Normal female	415	1.80	—	—	—	—	—	—	—	116	128	18	21	Mature Stage IV	Similar to right	10	0.516	—

TABLE I B

Parasitized female	432	1.54	—	—	—	—	—	—	—	103	142	17	30	Mature Stage IV	Externally Stage V Internally immature ova	8	Rt. lobe 0.182 to 0.492. Lt. lobe 0.165	8th Nov. 1958
Normal female	432	1.80	—	—	—	—	—	—	—	127	139	18	20	Ripening Stage V	Similar to left.	13	0.516 to 0.528	

TABLE I C

Female with the divided Right Ovary	405	1.70	—	—	—	—	—	—		Upper lobe 56 Lower lobe 54	137	Upper 16 Lower 12	18	Maturing Stage II	Similar to left	8	0.231	13th April 1959

fold. The lower lobe is connected to the left ovary through a common oviduct as in normal specimens. The measurements are given in Table IC.

Parasitized Ovary

(Fig. 4)

Normally, although, the left ovary is slightly larger than the right one, such a disparity in size as seen in this case is uncommon. The measurements are given in Table IB.

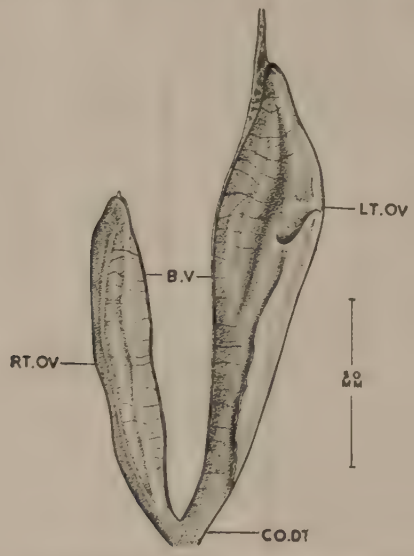

Fig. 4. Parasitized ovary. Abbreviations as in Fig. 1.

The parasitized left ovary, except for its very thin layer of soft, outer covering with immature ova below in certain places, is very much hardened and ' woody '. Excepting the transparent immature ova along the periphery all the other ova are completely destroyed. On the other hand in the normal right ovary where no parasites are found, in addition to the immature ova, yolky, maturing and mature ova ranging in diameter from 0.182 to 0.495 mm. are found. It is interesting that only one side should be affected.

The distribution of the larval nematode worms inside the left ovary is not uniform. Instead they are enormously congregated at the distal end where the regions occupied by them are black in colour. Figure 5 and Table II show the distribution of the worms in different regions.

The irritation due to the presence of worms inside and consequently the tissue-reaction and the remnants of destroyed ova are probably the cause for the enormous development and hardening of the left ovary.

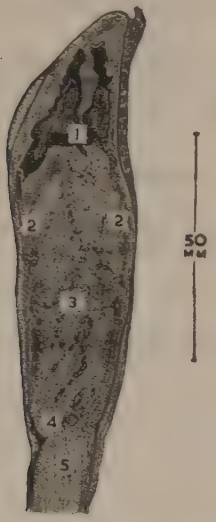

FIG. 5. GROSS Longitudinal section of the left parasitized ovary. Numbers indicate the different regions of sampling to show the distribution of the nematode worms (Refer Table II).

TABLE II

Regions examined (Fig. 5)	No. of worms per gram of tissue (estimated and corrected to the nearest hundred).
1	56,000
2	7,500
3	2,500
4	1,800
5	400

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J. Mar. biol. Ass. India, 1960, **2** (1) : 103-104

SPRATELLOIDES DELICATULUS (BENNET) AS A POTENTIAL LIVE-BAIT FOR TUNA IN THE LACCADIVES

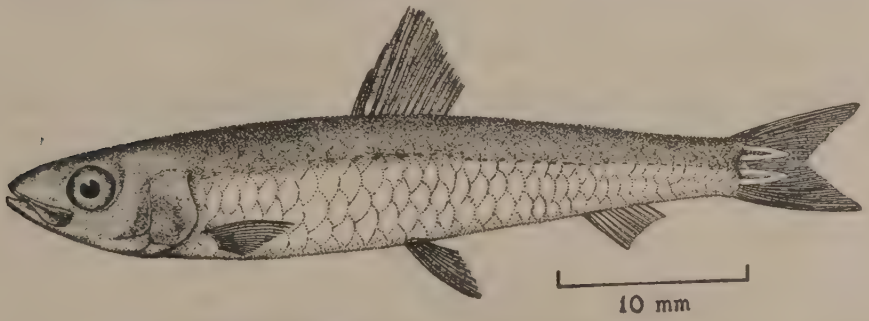
By S. Jones

Central Marine Fisheries Research Station, Mandapam Camp

Tuna fishing on an organised scale exists only in Minicoy among the islands of the Laccadive Archipelago (Jones & Kumaran 1959). Though the oceanic skipjack, *Katsuwonus pelamis* is widely distributed in the Laccadive Sea, a fishery for it is non-existent in any of the other islands. One of the reasons attributed for this is the absence of suitable baitfish in the lagoons of these islands while the Minicoy Lagoon abounds in a variety of small fishes which are caught and utilised for the purpose (Jones 1958).

During the third cruise of R.V. *KALAVA* in the Laccadive Sea (Jones, 1959) the vessel was anchored just outside the reef at Bitra (Lat. 11°. 38′ N. Long. 72°. 13′ E) close to Station No. 445 on the night of 27-4-1959. The anchorage was about a mile from the island in about 7 fathoms of water. As darkness set in and the ship's lights were switched on the whole sea around became live with millions of small fish which actively darted about on the surface. Wherever the search light was directed the congregation became most dense and the fish leapt about in a state of frenzy with their silvery sides shimmering in the light. It was a most remarkable sight the like of which was not seen previously by any on board the vessel. This activity continued as long as the lights were on in spite of intrusion by other fishes.

Several samples were collected with scoop nets and it was found that they comprised of the white bait, *Spratelloides delicatulus* (Bennet) (vide text-figure). The range in length was from 31 mm. to 51 mm. Some specimens kept alive in a bucket with occasional change of water remained in good condition for over 36 hours after which they were accidently lost.



Spratelloides delicatulus (Bennet) from the Laccadiva Sea

On the next day (28-4-1959) the ship proceeded to Agathi and was anchored outside the reef (Lat. 10°. 51′ N. Long. 72°. 28′ E) for the night. There, only stray specimens of *S. delicatulus* were collected near the light along with other fishes

and the abundance was in no way comparable to that at the Bitra Anchorage on the previous day. This species has not been collected so far from the vicinity of any of the other islands in the Laccadives.

Spratelloides delicatulus (=*Stolephorus delicatulus*) is one of the Dussimeridae growing to about 8 cm. with a fairly wide distribution in the Indo-Pacific, having been recorded from South Africa, Mauritius, Indonesia, Philippines, Samoa, Australia and in the Central Pacific Region in and around the Hawaiian Islands. June and Reintjes (1953) refer to its occurrence in large numbers in the Leeward Islands where it could be captured by means of a lift-net after attracting the fish with a submarine light and recommend the species as an excellent live-bait for pole and line fishing.

There does not appear to be any previous record of it from Indian waters. The specimens from the Laccadive Sea show the following meristic variations : D.ii, 10-11 ; P_1.i, 11-12 ; P_2. ii, 9 ; L.l. 35-38 ; Predorsal scales 10-11 ; gill-rakers on the lower limb of outer arch 24-29. Larval and juvenile stages of this collected from there are being described elsewhere.

In the Pacific various clupeoid fishes of the families Stolephoridae and Engraulidae are used as live-baits for skipjack fishing. The most important among these are *Cetengraulis mysticetus* in the Eastern Tropical Pacific from Mexico to Peru, *Engraulis japonicus* in Japan, and *Stolephorus purpureus* in Hawaii. In the Indian Ocean, live-baits are used for tuna fishing only in the Maldives and in Minicoy in the Laccadives, where they consist of a variety of nonclupeoids collected from the lagoons. It will therefore be interesting to study the extent of availability of *Spratelloides delicatulus* in the Laccadive Sea and experiment on its suitability as a bait-fish for tuna fishing.

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STUDIES ON INDIAN COPEPODS I. *PARALEPEOPSYLLUS MANNARENSIS*, A NEW GENUS AND SPECIES OF CYCLOPOID COPEPOD FROM THE GULF OF MANNAR*

By A. N. P. Ummerkutty

Central Marine Fisheries Research Station, Mandapam Camp

Thompson and Scott (1903) in their supplementary reports of the faunistic survey of the Pearl Oyster Fisheries of Ceylon reported on a number of copepods, many of which were new to science. Two of the new species, *typicus* and *ovalis*, both belonging to the genus *Lepeopsyllus*, which was also newly erected, were remarkable in their general resemblance to the members of the harpacticoid family Peltidiidae, especially in the shape of the body, in the posteriorward growth of the last prosomal segment and the complete overlapping of the urosome by the latter so that when viewed dorsally only the caudal rami are visible besides the prosomal region. A flattened oval or circular body as seen in *Lepeopsyllus* Thomp. and Scott is shared by many other cyclopoids and the prosomal segments may exhibit varying degrees of expanded growth posteriorly or laterally. But in all such instances the urosome is never fully covered over by the prosome. In *Lepeopsyllus*, however, the last prosomal segment grows over the urosome so that the latter is hidden by the former. Nevertheless a study of the various appendages of this copepod shows beyond doubt that it is a siphonostomous cyclopoid, very much related to dyspontiids, and understandably Thomspon and Scott placed this genus under Asterocheridae of Giesbrecht which in fact is included in the Siphonostoma by Sars (1918) wherein he groups together all those cyclopoids having a siphon in the oral region. Wilson (1932) included the genus *Lepeopsyllus* under the family Dyspontiidae Sars, and placed it very near *Dyspontius* Thorell and *Cryptopontius* Giesb. Nicholls (1944) follows Wilson and treats it in the same way. In his brief systematic review of the different genera that should be included in the family Dyspontiidae, he states that *Lepeopsyllus* Thomp. and Scott is 'recognisable as belonging to this family', with no further comments. In a latter part of this paper I have tried to draw attention to all the distinctive characters of this genus which distinguish it from a typical dyspontiid. The very close affinities that exist between *Lepeopsyllus* and the present form described below, and their distinctness from all other cyclopoids in certain important morphological features appear to suggest the creation of a new sub-family or family for their reception ; this point is considered later (*vide infra*).

Paralepeopsyllus Gen. Nov.

Body thin, scale-like, oval or circular ; prosome 3-segmented and urosome 4-segmented in both sexes ; in the female, however, the first two proximal segments may be only partially separated; the urosome is completely overlapped by the

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ast prosomal segment ; the margin of all the prosomal segments thickly lined with papilla-like prolongations of irregular lengths, forming an ornamentation. Antennule 14-segmented in female, 12-segmented and geniculate in male. Antenna 5-segmented, the last segment carrying terminal spines ; the second segment carries a rudimentary endopod provided with terminal setae. Siphon rather short and shield-shaped, hardly reaching about two-third the length of first prosomal segment. Mandible consists of a thin linear blade and a 1-segmented palp carrying two terminal setae of unequal length. Maxillule with a bimerous basipod and two palpi of unequal length, both carrying tufts of setae at the apex. Maxilla 1-segmented, strongly built and carrying a stout terminal claw. Maxilliped 5-segmented and strongly built, the last segment having a strong apical claw. There are only three pairs of swimming legs ; the first and second pairs biramous and the last pair uniramous ; the rami of all the legs are 3-segmented. Caudal furca moderately divergent and cylinderical. Eggs carried in two ovisacs, attached on either side of the genital segment and covered over by the last prosomal segment.

Genotype : *Paralepeopsyllus mannarensis* sp. nov.

Paralepeopsyllus mannarensis sp. nov.

Material examined : In the first week of August, 1960 eight females and five males of this copepod were obtained from the sponge washings from the Gulf of Mannar off Vedalai. None of the females in this collection was carrying egg-sacs. In the last week of the same month two egg-carrying females were obtained from the same locality, but this time from crinoid beds.

The generic name of the present species refers to its systematic relationship and the specific name to the locality of occurrence. The holotype, the allotype and the paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station, Mandapam Camp and bear the registered numbers J. 525/3, J. 526/3 and J. 527/3 respectively. All the drawings have been made with the aid of a camera lucida and the description and the diagrams are based on the examination of many specimens.

Description.

FEMALE

Colour. Freshly captured individuals were transparent with beautiful shining ornamentations along the prosomal margins. Formalin preserved specimens became opaque with a pale yellowish tinge ; darker shades are present along the thickened areas. *Body.* (Fig. I, 1)—The body consists of the prosome and the urosome but the latter is entirely hidden beneath the former which actually accounts for the whole size of the animal. The prosome is oblong-oval with a clear rostral prominence on the anterior side. It consists of only three segments, the margins of all of which are greatly ornamented with papilla-like growths. The ornamentation of one lateral half roughly corresponds to that of the other half. The ornamented area appears to be thicker than the non-ornamented part. The first prosomal segment is much larger, both in length and width, than the other two segments combined. The second segment is broader than the third but distinctly shorter than the latter ; it is rather crescent-like with the two lateral edges much

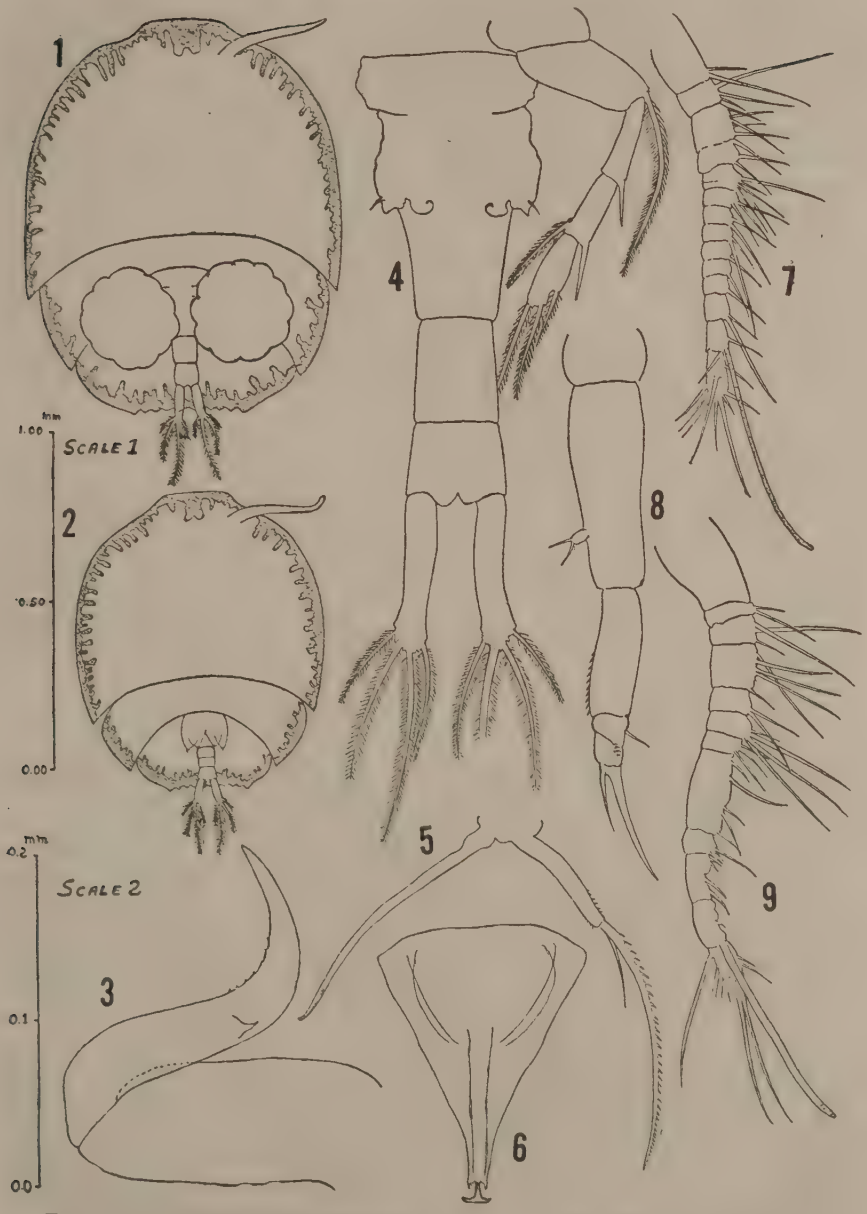

FIG. 1. *Paralepeopsyllus mannarensis* gen. et. sp. nov. 1. Adult female, habitus, ventral view. 2. Adult male, habitus, ventral view. 3. ♀ Maxilla. 4. ♀ Urosome with left third leg. 5. ♀ Mandible. 6. ♀ siphon. 7. ♀ Antennule. 8. ♀ Antenna. 9. ♂ Antennule. (The habitus of the adult male and female are drawn to scale 1, and all the appendages to scale 2).

thickened ; the ornamentation of this segment is broken from that of the first segment but appears to be continuous with that of the following segment. The last prosomal segment has a peculiar shape, with the highly convex anterior margin fitting into the concavity of the preceding segment and with the posterior margin being wavy ; the two lateral sides smoothly curve down to the posterior wavy margin which is less than half as long as the widest part of the same segment ; in the case of this segment the ornamentation is present both on the lateral and the posterior borders. The urosome consists of a genital segment and two abdominal segments ; the former, however, shows a partial division into first urosomal segment which in the related genus, *Lepeopsyllus*, bears the fifth pair of legs and the genital segment proper. It is longer than the two abdominal segments combined ; the genital segment proper exhibits a proximal wider and a distal narrower regions, a spine on either side being present at about the junction of the two. The genital segment carries a pair of ovisacs, one on each side. Of the two abdominal segments the proximal is the larger but they are of equal breadth. The last abdominal segment bears a pair of caudal rami which are cylindrical, rather elongated and slightly divergent. Each of them bears four setae of unequal lengths, the longest of them being only a little longer than the ramus itself.

Antennule (Fig. I, 7)—Compared with the size of the body the antennule is rather small and consists of fourteen segments. The first five segments as a whole, are distinctly wider than the next nine and the fifth segment shows a partial division. While the segments 6-11 are subequal, other segments are of varying lengths, with the first segment as the longest. All the segments are provided with setae, often many of them on a single segment. But the arrangement of the setae does not appear to give any clue to the number of original segments that would have fused together in the formation of the present condition. The thirteenth segment bears a fairly long aesthetask. The proportionate lengths of the antennular segments are as follows :

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
16·4	6·5	10·0	5·3	6·4	4·7	4·7	4·4	4·7	4·1	5·0	7·3	8·2	12·3	= 100

Antenna (Fig. I, 8). This is 5-segmented. The basal two segments form the basipod and the next three segments the endopod ; the exopod is represented by a bud-like structure that arises from anterior margin of the second basipod segment ; the first basipod segment does not bear any accessory structure. The first endopod segment is devoid of any seta or spine but are provided with very small spinules along its distal anterior margin ; second endopod segment bears a slender spine on its posterior margin and the last segment two terminal spines of unequal length ; there are a few small spinules arranged obliquely along its length on this last segment. *Siphon* (Fig. I, 6). This is rather short and pyriform, hardly reaching the two-third length of the first prosomal segment. Its distal part is very narrow, about one-tenth of the wide proximal. The former bears a club-shaped structure at the middle of its concave tip. *Mandible* (Fig. I, 5). Consists of a masticatory blade and a palp which is less than half the length of the former ; the palp has its distal one-third margin ciliated and bears two terminal setae ; one of the setae is slender and short while the other is quite large, equal in length to the masticatory blade and bearing sharp spinules along its entire length on one side. The masticatory blade is slender and long, the thick basal part gradually diminishing in width to the distal tip which is serrated. *Maxillule* (Fig. II, 10). Is composed of a basipod which is indistinctly divided into two segments and a pair of lobes arising from it. One

of the lobes is much larger being about two and a half times thicker and longer than the other ; the former bears four setae which are graduated in length and the latter five setae of varying lengths. Along the inner margin of the larger lobe there is a row of spinules. *Maxilla* (Fig. I, 3). Maxilla is peculiar in being uniarticulated with no trace of division. It is large, cylindrical and devoid of any seta or spine except the terminal claw ; the latter is very large and stout and has a characteristic shape in the form of a reversed ' S '. There are a few minute spinules on its distal inner margin and a separate miniature claw just beyond its middle bent. *Maxilliped* (Fig. II, 11). Fairly large and consists of five segments, the fifth segment bearing two terminal spines, one of which is much larger than the other. The segments are uneven in their lengths ; second segment is the largest and the fourth the smallest ; the latter bears a small spine on its inner margin.

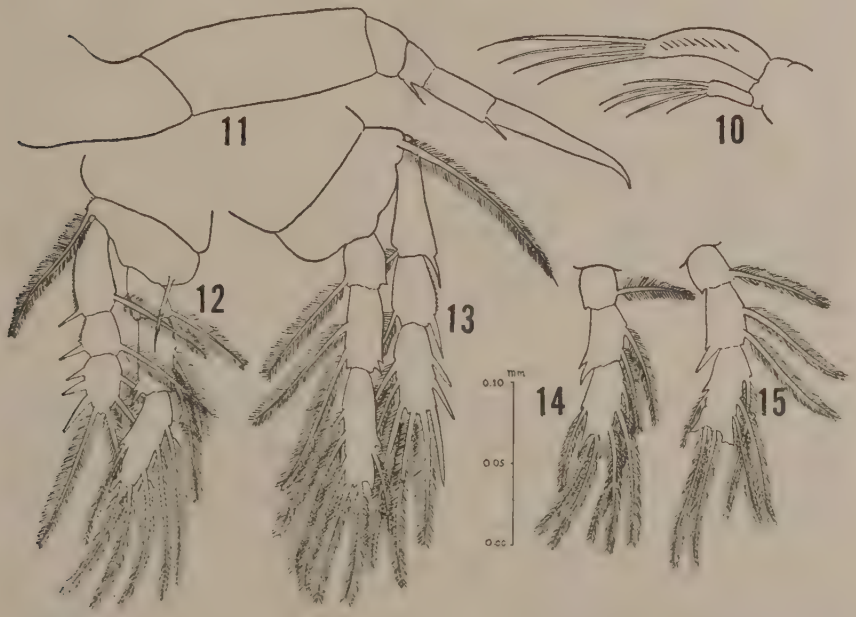

FIG. II. *Paralepeopsyllus mannarensis* gen. et. sp. nov. (contd.) 10. ♀ Maxillule. 11. ♀ Maxilliped. 12. ♀ First swimming leg. 13. ♀ Second swimming leg. 14. ♂ Endopod of first swimming leg. 15. ♂ Endopod of second swimming leg.

Swimming legs (Fig. II, 12, 13). There are only three pairs of swimming legs. Fourth and fifth legs are entirely lacking. They are borne by the three prosomal segments. The first two pairs of legs are biramous while the third is only uniramous. Each ramus is composed of three segments. In the first two pairs of legs, constituting segments are rather elongate ; even when it is short, the segment is distinctly longer than wide. In the first leg the exopod is shorter than the endopod while in the second leg the reverse situation is true. The basipods in both cases are stumpy and broad, the first basal bearing no setae or spine and the second basal bearing one

seta and one spine in the case of first pair of legs, and one seta alone in the case of second and third pairs of legs. In the third leg the endopod is entirely lacking ; the exopod is rather slender, the segments subequal ; in the basipod the basal one is short and broad while the basal two is quite long bearing the exopod almost at right angles to its length. The setal formula for the swimming legs is given below :

Following Sewell (*loc. cit.*) I have used Arabic numerals to indicate setae and Roman numbers for spines.

	Basipod				*Endopod*							*Exopod*						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P^1	0	0	I	1	1	0	1	0	3	2	1	1	I	1	I	3	1	III
P^2	0	0	0	1	1	0	2	0	3	2	1	1	I	1	I	3	2	III
P^3	0	0	0	1	Absent							0	I	1	I	0	1	1+1

The absence of the fourth pair of legs is the consequence of the absence of fourth prosomal segment. However, the fifth legs also are entirely lacking although the fifth leg-bearing segment is present in partial union with the following genital segment. The length of the female is 1·2 mm.

MALE

The male (Fig. I, 2) is much smaller than the female and shows sexual dimorphism in the structure of antennule, urosome and in the endopods of first and second pairs of legs. The urosome is clearly 4-segmented ; the first of these segments is the result of the fusion of the original fifth leg-bearing segment and the genital segment. The next three segments constitute the abdomen and are postgenital in origin. The first segment is three times wider and three times longer than the abdominal segments combined. It is barrel-like and carries a pair of spines on each of its posterior corners. The abdominal segments are subequal, the last of them bearing the caudal rami. The latter in male appears to be as long as the last two abdominal segments combined, while in the female it is definitely shorter.

Antennule (Fig. I, 9). Is geniculate and consists only of twelve segments. First segment is the largest and may be compared to the corresponding segment in the female. The last two segments also are comparable to their female counterparts for, the penultimate segment here also bears the aesthetask. The identity of other segments are not clear. All the segments are provided with setae, while segments 9-11 also carry a few spines. The proportionate lengths of the various segments are given below :

1	2	3	4	5	6	7	8	9	10	11	12
17·7	3·8	5·5	9·1	5·3	4·8	4·3	16·8	5·0	10·0	10·0	7·7 = 100

The variations in the structure of the endopods of the male first and second legs (Fig. II, 13, 14) are not very profound. In the first endopod it consists in the presence of spinous growths on either distal corner of the third segments while in the female this spinous process is present only on the outer corner. In the second endopod the male has its distal corners of the third segment produced into peculiar structures, the outer of these is conical and serrated on the outer margin while the inner is irregular ; in the female there is no structure corresponding to this latter ; but the outer conical process is the counterpart of the spine in a similar position in the female.

Discussion

There are a number of characters which the present genus shares with the genus *Lepeopsyllus* Thom. & Scott. Some of these are peculiar to these two genera while some other features are exhibited by the members of one or other related families. The characters shared by these two genera are indeed substantial, the most notable of them being the exceedingly large development of the prosomal segment, especially the last one. The nearest approach to this condition is apparently met with in the genus *Micropontius* Gooding, 1957 (Family Micropontiidae). But the differences between *Micropontius* on the one hand and *Lepeopsyllus* and *Paralepeopsyllus* on the other, are too many to establish any real relationship between them. Among other siphonostomous cyclopoids an expanded growth of the prosomal segments is possessed, to some extent, by the members of the families Dyspontiidae, Artotrogidae and Cancerillidae ; but in all these cases the last prosomal segment always remains small and inconspicuous. However, in the genus *Discopontius* Nicholls, 1944 (Dyspontiidae) the prosome is very large and the last prosomal segment grows posteriorwards, covering not only the first urosomal segment but also a part of the genital segment. This tendency of *Discopontius* to a backward development of the last prosomal segment seems to indicate a genuine kinship with *Lepeopsyllus* and *Paralepeopsyllus*, for there are a number of other features which also point to this conclusion.

In *Lepeopsyllus*, the prosome is 4-segmented, each segment bearing a pair of swimming legs. First segment is far larger than the entire remainder of the body ; next in size comes the last segment which, although only half the size of the first segment, still constitutes a major part of the body and grows over the urosome, fully covering the latter ; second and third segments are rather thin strips, inserted between the first and the last segments. In *Paralepeopsyllus*, a similar situation exists, but the process of reduction has gone still further with the result that there are only three segments in the prosome, each bearing a pair of swimming legs. In size, the first segment remains the largest, accounting for more than half of the body, while the last segment is the next larger and covers the entire urosome dorsally ; the second segment forms a crescent-shaped strip of body between the first and the third segments.

The marginal ornamentation of the prosomal segments also deserves some comments : this character is peculiar to these two genera among the cyclopoids ; a nearest comparable feature found among other genera, such as *Micropontius*, is the thickening of the edges and margins of the prosomal segments. Both are probably for imparting strength to the region, but their morphological history appears to be different. Another character not usually known for the siphonostomous

cyclopoids but is noticed in the present genus is the slight structural modifications of the first and second swimming legs of the male. The terminal segment of the endopods of these legs exhibits an expanded development as is described in an earlier part of this paper. Unfortunately this point cannot be discussed as the male is yet to be known for the related genus, *Lepeopsyllus*.

It has been pointed out earlier that both Wilson (*loc. cit.*) and Nicholls (*loc. cit.*) have included *Lepeopsyllus* under Dyspontiidae. One should presume that this was done so only because of the absence of a different family suitable for its reception, rather than by its agreement with the genuine features of a typical dyspontiid. In dyspontiid, the antennule consists of a reduced number of segments and is not divided into a proximal wider and a distal narrower region, except in *Discopontius* where the first two segments are distinguished from the rest by their larger size. In fact, the division of antennule into a proximal wider and a distal narrower region is a condition usually found in Asterocheridae. Further, the geniculate male antennule of the members of Dyspontiidae contains usually an equal or a larger number of segments than the corresponding structure of the female. But in Asterocheridae and in the present genus the reverse is true, namely, the geniculate male antennule is composed of a smaller number of segments than the corresponding organ of the female sex. The structure of the antenna is still more striking. It is 5-segmented both in *Lepeopsyllus* and *Paralepeopsyllus* (although Thompson and Scott state that it is 4-segmented, their diagrams clearly show 5-segments) as it is in most of the asterocherids, while in all dyspontiids it invariably consists of four or less number of segments. The resemblance of these two genera with asterocherids in the structure of the antenna becomes complete when one takes into account the proportionate lengths of the constituting segments. In these forms, the second segment which bears rudimentary exopod is the largest, being equivalent to or larger than the combined size of the next three segments ; while the third and first segments come next in order of size, the last two segments are extremely small and subequal ; the terminal segment bears one or more strong spines. In dyspontiids the last two segments are never so small compared to the size of other segments. Further, although the second segment is still the largest, it is not equal to or longer than the combined length of the two following segments, the only exception, again, being *Discopontius* Nicholls.

It may be noted that the genus *Paralepeopsyllus* tends to exhibit certain similarities with the Artotrogidae and Cancerillidae, especially in the reduction of the posterior pairs of legs. The Artotrogidae differs from Dyspontiidae essentially in the total absence of the fourth pair of legs, in this respect approaching the Cancerillidae ; the latter is, however, distinguishable very easily by the enormous development of antennae which are unlike those in any other siphonostomous family. The reduction in the number of legs, however, need not be taken as a close relationship between *Paralepeopsyllus* and Artotrogidae, for they are quite separated in many other morphological features.

This tendency has been prevalent even in Dyspontiidae where the fifth leg is highly reduced in all the genera ; and the endopod of fourth leg is entirely lacking in a number of genera such as *Dyspontius* Thorell, 1859, and *Cryptopontius* Giesbrecht, 1889, while in some others like *Bradypontius* Giesb. 1895, *Arctopontius* Sars, 1915, *Discopontius* Nicholls, 1944, *Sestropontius* Giesb. 1899, *Metapontius* Hansen, 1923 and *Cribropontius* Giesb. 1899 the endopod is reduced in size. In

the genus *Pteropontius* Giesb. 1895 not only is the endopod of fourth leg absent but the rami of the first legs are only 2-segmented, thus exhibiting a tendency for the reduction of other appendages also. It may be only contended that this tendency for a reduction in the number of the swimming legs or their constituting segments has been present in the evolution of different groups of siphonostomous cyclopoids.

Thus it appears clear that the genera *Lepeopsyllus* and *Paralepeopsyllus* constitute a natural group, sharing many peculiar features distinct from those of all other siphonostomous cyclopoids. These two genera retain many characters of the family Asterocheridae found in such structures as the antennule and the antennae and combine them with those of the family Dyspontiidae. However, this is a little known group ; *Lepeopsyllus* is known only from two species, *typicus* and *ovalis*, both based on one or two individuals and *Paralepeopsyllus* is a monotypic genus. Until more species and genera related to these are known it would probably be unfair to erect a new family for accommodating them, although their distinctness is clear enough.

Discopontius referred to above may also be briefly considered here. As pointed out earlier this genus deviates from the definition of typical dyspontiids in a number of ways : (*a*) in the tendency of the prosomal segments to grow posterior-wards over the urosome ; (*b*) in the apparent division of antennule into a wider proximal and a narrower distal region ; and (*c*) in the proportionate lengths of the antennal segments. In all these features the genus tends more towards *Lepeopsyllus* and *Paralepeopsyllus* than to any other member of the family Dyspontiidae. Probably these three genera are not true dyspontiids at all ; or the family Dyspontiidae need to be redefined to include them all.

Summary

Paralepeopsyllus mannarensis, a new genus and species of cyclopoid copepod is described in detail ; it is an inshore-dwelling form, living in association with invertebrates such as sponges and crinoids ; the species is known from both the sexes.

The genus is related to *Lepeopsyllus* Thompson & Scott and its systematic position is very near to that genus. The very close affinities that exist between these two genera and their distinctness from other cyclopoids appear to justify their inclusion in a separate family. The arguments in favour of and against this postulation are discussed.

Acknowledgements

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MODERN TRENDS IN MARINE BIOLOGY*

By Prof. R. V. Seshaiya
Director, Marine Biological Station, Porto Novo, Madras State

'One may not doubt that, somehow, good
Shall come of Water and of Mud
And sure the reverent eye must see
And purpose in Liquidity.'

Rupert Brooke.

Friends,

I am thankful to you for asking me to participate in the annual meeting to-day. The annual report presented by the Secretary has told us of the good progress which our infant association has made during the first year of its life. This augurs well for the future of the Society. In the coming years, marine biology will play an increasingly important role in the advancement of the sciences of life, and I am sure that the establishment of the Marine Biological Association of India in 1959 will prove to be a significant event in the progress of science in India.

But the achievement of our aims will depend upon the orientation of our efforts to the new horizons in marine biology. An occasion like the annual meeting to-day is appropriate for exchange of ideas, and I accordingly propose to speak briefly on some recent trends in marine biology, with a view to stimulating discussion on the subject.

I note from the Secretary's report that the lay public have been taking an active interest in our association. This impact of marine biology on society is an important trend, and is increasingly evident in countries where marine biological science has been established for some years. For the progress of science, and for science to serve properly as an intellectual tool in appropriate spheres of human activity, scientific thinking has to enter into the warp and woof of the intellectual fabric of human society and should be properly integrated with other intellectual activities. In our country, our national genius has not so far found expression in scientific achievements to the same extent as it has in other spheres like poetry or art, or as in many other countries. This is particularly true of the sciences of the sea. Notwithstanding our coast-line of 3,500 miles, we tabooed the '*Kala pani*' and in neither poetry nor art has the sea proved to us a source of inspiration as it has for some of the English poets.

But it is for another reason that I value this impact of marine biology on society. The advancement of marine biology, as I pointed out before, will contribute much to a better understanding of the phenomena of life and life-processes than at present.

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* Talk delivered at the first General body meeting of the Marine Biological Association of India on 20th December 1959.

This will help us to widen our intellectual outlook, and an intimate and fuller knowledge of the economy of life in the sea and its viscissitudes may ultimately help us to at least reassess some of our social philosophies.

These social and academic values can be adequately realised in marine biology only when it has attained the full status of a scientific discipline. But this has not yet happened. Marine biology may be said to have its origin about the middle of the nineteenth century in the discovery by Johannes Müller that multitudes of minute organisms exist in the surface layers of the sea, and in the erroneous observation by Edward Forbes that life does not exist in the sea below three hundred fathoms. During the last hundred years marine biology has grown in an unconventional way through contributions from diverse sources. The observations of enterprising naturalists, the results of exploratory voyages, clues from other scientific disciplines, the demand for exploitation of the sea for protein food, investigations undertaken for navigational purposes and the establishment of shore-based biological stations for continued long-term observations have all contributed to shape the marine biology as we see it to-day. But casual observations from such varied sources cannot be easily blended into a unified scientific discipline. As Kant stated : ' Accidental observations cannot be necessarily united into a Law'. Science does not consist only of finding facts ; nor is it enough if we rationalise without facts. To quote again from Kant, ' the principle of reason alone can give concordant phenomena the validity of laws, and experience must be directed by these rational principles to have a real unity.' The processes of science are characteristic in that they move by the union of empirical fact and thought, by the analogies of experience, as Kant termed it. The phenomenal development and the great precision attained by the physical sciences have been through this process of linking rational and empirical conceptions. How far has marine biology progressed in this direction ? It is only in recent years that marine biology has begun to develop exactness and attempt at hypothesis to predict events in the sea. In other words a recent trend in marine biology is the inception of its growth into a science.

The abundance of organism in the sea is so great and impressive that the main interest in marine biological investigations centre on population studies. The growing trend in marine biology toward achieving exactness and ability to predict events in the sea is most evident in population studies.

The practical importance of population studies, as is well known, is in relation to Fisheries. A correct assessment of fish-stock versus fishing effort and the prediction of future abundance by analysis of the causes of fluctuations in fish stocks are essential in fisheries. As early as 1914, Johan Hjort drew the attention of marine biologists to the importance of investigating the causes of fluctuations and failures in the important fisheries of Northern Europe and West Atlantic. Since then there has been a growing recognition of the importance of this problem and the urgent need for continued and coordinated investigations in order to analyse not only the seasonal and annual changes but also the long-period fluctuations that seem to occur in populations.

During the last thirty years some important studies have been made to analyse these short-period, as well as long-period fluctuations in populations. The causes of seasonal and annual changes in populations are relatively easy to understand. But the causes of the long-period trends in population are not easy of analysis. One of the best documented studies is by the Plymouth School of Marine Biology, which

has investigated the change in the phosphate content, current patterns and fertility in the English Channel for over twentyfive years. The decline in the Pacific halibut fishery was traced by Thompson (1937) to overfishing and the improvement of the fishery was achieved by regulation of the fishery. But the view that the decline in fishery was caused by overfishing was criticized by Burkenroad (1948), who regarded the change in abundance as primarily a 'long-term fishery independent', trend or oscillation. The occurrence of natural fluctuations or oscillations must be admitted, but it is unlikely on *a priori* grounds. Beverton and Holt (1957) point out, that there has been in this instance ' a temporal coincidence of fishery limitation and a sudden change in stocks in a favourable direction '.

The occurrence of regular natural fluctuations with a peak of abundance every fourteen years has been demonstrated by Burkenroad (1948) on the basis of evidence gathered by him on the relative abundance of starfish in Southern New England waters during the last hundred years. The possibility of these oscillations being due to internal biological control has been suggested by Burkenroad (1948).

These population studies illustrate the union of empirical facts and theoretical methods, which we said, is the distinctive feature of science. The adoption of this procedure in marine biology is a significant trend. The concept of the dynamics of an open system is finding its application in marine biology with special reference to exploited fish populations. Beverton and Holt (1957) have extended the concept, regarding the open system itself as but one element in a higher system, comprising all other interdependent biotic factors.

A population can also be viewed as a level of integration of organisms, where it is meaningful to speak of birth rate, sex ratio, age structure, growth form, and where there might emerge new properties conferring selective value on the species. The rich and varied populations inhabiting the seas provide excellent opportunities for understanding these properties of populations which may help us to obtain a better insight into the problems of our own species.

In population studies the emphasis is on the relations between the individual and its neighbours of the same species within the sphere of its distribution, and the population is regarded as a community of individuals, all having a definite growth. Another equally important concept in marine biology is the ecological concept, in which the emphasis is on the resemblances between the different species in their physiology and in their relationships with the environment. When we speak of phytoplankton or zooplankton, we ignore the taxonomic categories. The ecological unit is an integration of different species and has a remarkably consistent behaviour and pattern irrespective of the species composition. It is in this ecological approach that we see some of the most pronounced trends in marine biology.

The earlier ecological studies were descriptions of natural history and faunistic lists. But now employing quantification and statistical analysis, the concept of ecological unit has emerged, and we are now beginning to be interested in the dynamics of the ecosystem.

There have been striking developments in the collecting and sampling techniques and in the quantitative assessment of plankton, benthic organisms etc. The analysis of the environment also is becoming more thorough and, it seems as Rae

(1958) pointed out the gross physical and chemical parameters are not the all-important ones but the less obvious factors, like micronutrients, trace elements, vitamins, external metabolites etc., may play the prime role in determining many of the variations of marine population in time and space.

Another trend in marine ecology has been the introduction of parallel experimental methods in the laboratory and field, especially for planktonic studies, and Rae (1958) has pleaded for the establishment of a school of plankton husbandry.

Some of the significant contributions to the new picture of marine ecology have been in connection with the studies in productivity, plankton relationships and movements. The investigations on the phosphate cycle in the English Channel by Armstrong and Harvey, and the productivity studies in the same region by Harvey, have given us a clearer idea of the ecological group, which we may now conceive as a dynamic system for the transformation of energy. We may ultimately look to a time when we may be able to define the ecological unit as an open system and explain its energetics in relation to environment and life-history.

How complicated the problem is, we may realise if we remember that the environment is not much less complex than the organism. Loosenoff in his excellent work on *Crassostrea virginea* examined over 1,500 relationships in order to determine variables which may correlate with biological variables.

The importance of the biological economy of the sea can be realised from the fact that, of the fraction of the solar energy that is utilised for photosynthesis in the world, nine-tenths is accounted for by marine plants, and one-tenth alone by the land plants.

Marine ecology is rapidly growing along several lines, establishing links not only with other aspects of marine biology but also with palaeogelogy and geochemistry. Even more than population studies, ecological studies demand long-term programmes in which the investigators work in the same area and on the same problems for long periods.

In this connection I would like to explain with an analogy the relationship of marine biology to oceanography and fishery biology. The world of human experience can be diagrammatically represented by three concentric circles, of which the outer represents the cosmosphere, the middle the biosphere or realm of life, and the inner the sociosphere of which man is the centre. Oceanography would correspond to the cosmosphere, marine biology to the biosphere, and fishery biology, which has direct human value, to the sociosphere. All these branches are dynamically interrelated and have some common areas of investigation like hydrography. This interrelationship is becoming increasingly evident in research projects undertaken in various institutions.

The dynamic trends in marine biology, which we illustrated with reference to population studies and ecology, are also seen in the attempts to explain marine biological processes in biochemical terms. It is now generally recognised that the most significant development in modern biology is the consistent effort to bring to molecular or biochemical level the classic problems of morphology, development, inheritance, evolution and ecology. Marine biology offers an exceptionally rich scope for this new approach. The origin and evolution of life, evolution of metabolic patterns and the adaptations of organisms to overcome ecological barriers and colonise new

habitats, migrations, interrelationships of organisms, productivity, and a host of other problems can have illuminating analysis with a biochemical approach. It is becoming increasingly evident that there is a common fundamental biochemical ground plan to which all living organisms conform, and superimposed on this are numerous secondary and specific systems, which are mostly adaptional in character.

The importance of the biochemical approach is illustrated by the interesting way in which marine biological investigation was grafted to research in dairying at Reading, and investigations on whales and planktonic organisms were linked with problems connected with vitamin A in cow's milk. It seems as though even dairy research has a 'sea change'! Equally interesting aspects of the biochemical approach are seen in the study of external metabolites and distribution of vitamin B^{12}. The suggestion has been made by Kon (1958) that the study of the fluctuations of water-soluble metabolites and vitamins in relation to planktonic successions and blooms will be a fruitful feature of the marine biochemistry of to-morrow. The same investigator has strongly pleaded for research vessels in future to hunt for specimens, not for enshrining them in formalin but for investigations in dynamic biochemistry.

I have so far discussed a few of the modern trends that promise to forge marine biology into a unified science and bring into existence some order out of the chaos of observations and data that have been collected so far.

I now pass on to a brief review of a few other developments in marine biology. Marine biology has kept pace with technological developments in science, and has pressed into its service several technical devices undreamt of before, including television and underwater photography. But it is not only the physical and technological sciences that have influenced the trends in marine biology. The study of the, behaviour of marine organisms has become significant in marine biology. Recently, Waterman (1958) has suggested that the behaviour of certain pelagic forms may be determined by polarised light. Miyadi (1958) has pointed out with experimental evidence that for purposes of obtaining really useful knowledge to control fish production, it is advisable to make comparative studies on the social life of fishes both by experiments and in nature.

Thus marine biology seems to be establishing contacts with various scientific disciplines and even sociology and philosophy. But what about its relation to classical and academic biology? Marine biology awaits installation in its rightful place in general biology. Modern biological theories and experiments have been in a large measure without reference to marine life. In the wealth and variety of marine life there is unexcelled scope for investigations that will open new horizons in genetics, cytology, cytogenetics and experimental evolution. Our biological theories can neither be conclusive nor balanced until we are able to discover and use what Rae (1958) termed the marine equivalents of the guinea pig, mouse and *Drosophila*. Yes, biology as a whole will have to undergo a 'Sea change.'

Reviewing the modern trends in marine biology, we feel that the task ahead of us is tremendous, and so are the qualifications and intellectual equipment for undertaking the task. Marine biology is growing into a synthetic and exact science, and the sea with the life in it has to be studied as a dynamic whole. Like several rivers flowing into the sea and merging with it, the various intellectual disciplines are merging in marine biology. In thinking of the vastness of the subject we cannot help being reminded that, 'into the Kingdom of knowledge, as into the Kingdom of Heaven, whosoever would enter must become as a little child.'

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MARINE BIOLOGICAL AND OCEANOGRAPHIC INSTITUTIONS OF THE WORLD

III. THE BINGHAM OCEANOGRAPHIC LABORATORY

By Alice M. Child

Bingham Oceanographic Laboratory, Yale University, New Haven, Conn.

When Harry Payne Bingham, 1910, presented his private marine collection of deep-sea fishes to the Peabody Museum in 1930. the Bingham Oceanographic Laboratory became a reality. Its first staff member was Albert Eide Parr who later became Director, a post which he held until 1942 when he was succeeded by Daniel Merriman. Under Dr. Merriman's leadership, the staff increased to about a dozen people, plus several graduate students each year, all of whom performed various duties in connection with the Laboratory's program of teaching and research in oceanography.

Housed for the past two decades in a Victorian mansion on Hillhouse Avenue (the Peabody Museum Annex), the staff converted upstairs sleeping quarters into offices and laboratories. The lofty panelled ballroom of the old house provided nearly sufficient space for an extensive scientific library, and brick-paved wine-cellars in the sub-basement were utilized as aquarium rooms. But such quarters, designed for gracious living in the ample style of the '80s, still lacked certain twentieth century amenities essential to the operation of a modern research laboratory. Light, air, well-planned space, up-to-date water systems for feeding aquarium tanks, machinery for temperature control, heavy-duty wiring for complicated electrical equipment—all these aids to research were either conspicuous by their absence or at best ingenious makeshifts. Even in the 1940s it became increasingly clear to the new Director that some sort of physical expansion would eventually have to be provided if high standards of research were to keep pace with new developments in oceanography, and teaching facilities were to be adequate to meet the new demands of the future.

And so, on October 30th, 1959, a new and modern building—the gift of the Bingham family and of Wendell W. Anderson, 1922, and William Robertson Coe, 1949 hon.,—was dedicated at a brief ceremony and presented to Yale University. Over 500 guests attended the dedication ceremonies which were held, appropriately enough, in the remodeled ballroom of the Bingham's old quarters. After these short formalities, the guests were taken on a tour of inspection of the new building, and ended their tour in the Dinosaur Room of the Peabody Museum, where toasts were drunk to the continued success and good fortune of the Bingham Oceanographic Laboratory.

The culmination of years of planning by the Directors of the Bingham Laboratory and the Peabody Museum, and their combined staffs, the Bingham's new home is one phase of the building expansion program of scientific facilities at Yale. This

latest development for the benefit of the natural sciences incorporates many interesting features, one of which is the series of six connecting rooms on the ground floor, four of them containing aquarium tanks which are being used for experimental purposes. These four rooms have separate temperature controls, and the aquaria are supplied by both fresh and salt-water circulating systems, 6,000 gallons of sea water being circulated through tanks by a specially designed pumping system. The piping for this system is entirely of plastic, so that no toxic substances are given off to be absorbed by the fish. The fifth room in the series is equipped as an operating room, and the sixth room—the so-called ' Hot Lab '—is being utilized for work involving the handling of radioactive materials in connection with experimental work on fishes.

There are one or two offices, including the Director's, on the first floor, but most of the staff offices and laboratories are on the second. Also on the second floor is a large, well arranged library containing an irreplaceable collection of over 1,000 scientific journals, hundreds of books and 15,000 reprints. On the other side of the building a well equipped photography laboratory includes two dark rooms and a ' soft ray ' machine for X-Ray work on specimens.

In addition to the aquarium suite, the first floor of the Bingham Laboratory boasts several convenient working and storage facilities. A large cement-floored gear room has a distinctly nautical flavour, with nets, seines, and trawls suspended from an ingenious arrangement of overhead hooks and pulleys. Ranged on shelves along the walls are a variety of traps and cages used for collections ' in the field.' The fish specimen storage room with its hundreds of feet of steel shelving is rapidly filling up with specimens accumulated from recent expeditions. Due to lack of space, these extensive collections had hitherto had to be stored in all sorts of inaccessible spots round and about the University. A machine shop and a shipping room are located opposite double doors which lead into the building from an outside loading platform. At the end of the first floor corridor is a publication storage room containing a full set of files of the Journal of Marine Research and the Bulletin of the Bingham Oceanographic Collection, both of which publications are issued by the staff of the Bingham Laboratory, and date back to the early 1930s. Here also reposes a sizeable collection of reprints of the articles written by members of the Bingham staff for other scientific journals.

Also on the first floor is the Seminar Room. Designed to accommodate thirty or more students, this room is an important addition to the expanding program of teaching at the new Bingham Laboratory. Although oceanography is not a department per se at Yale and no graduate or undergraduate degrees are offered in this subject, graduate seminars in oceanography and ichthyology are being attended by students who are taking their doctorates in such departments as Zoology, Chemistry, Physics, Geology, Botany and Microbiology, many of whom are doing their research and preparing their theses under the supervision of the Bingham staff. Plans for the coming academic year include the addition to the teaching and research staff of both a chemical and physical oceanographer, and course offerings will be expanded accordingly.

That there is an acute and growing need for trained oceanographers is emphasized by the reports of the Committee on Oceanography of the National Academy of Science which, under the auspices of the National Research Council and the National Science Foundation, is engaged in exploring the predictable trends and scope of

oceanography which may be expected to prevail over the next ten years. There is obviously an increasing interest in matters oceanographic on the part of the public and, best of all, a constant stream of inquiries is pouring into the new Laboratory from prospective students who wish to qualify for this challenging field.

By gradually increasing its staff and expanding its teaching program, the Bingham Oceanographic Laboratory is on its way to meet the challenge of the future, a challenge with which, to quote the Director's speech at the Dedication last October, 'I assure you we will more than keep pace.' Exploiting to the fullest degree its splendid new physical plant without compromising the high standards of research set up by a small and dedicated staff in spite of great material difficulties, Dr. Merriman feels strongly that 'the free pursuit of academic knowledge for its own sake' must be made available to the rising generation of students of oceanography, a subject which is 'not a science, but the focus of many sciences.'

NOTES

ON AN EPIZOIC GASTROPOD, *SAPTADANTA NASIKA* PRASHAD & RAO, ON THE SHELLS OF *PTEROCERA* LAMARCK

A heavy infestation by a hitherto little known epizoic gastropod on a shell of *Pterocera lambis* (Linne) from Minicoy in the Laccadive group of Islands was brought to my notice by Dr. S. Jones, Chief Research Officer of the Central Marine Fisheries Research Station, Mandapam Camp. It was later identified by me as *Saptadanta nasika* Prashad and Rao under the family Lepitellidae. Several other shells of *P. lambis* (Linne) and *P.chiragra* (Linne) infested in a similar manner by the same species and reported to have been received from Mangalore were obtained subsequently from a chank godown of a shell dealer in Kilakarai, Ramnad district. The original description by Prashad and Rao (1934) of *Saptadanta nasika gen. et sp. nov.* was based on a specimen found on *Trochus niloticus* Linne from the

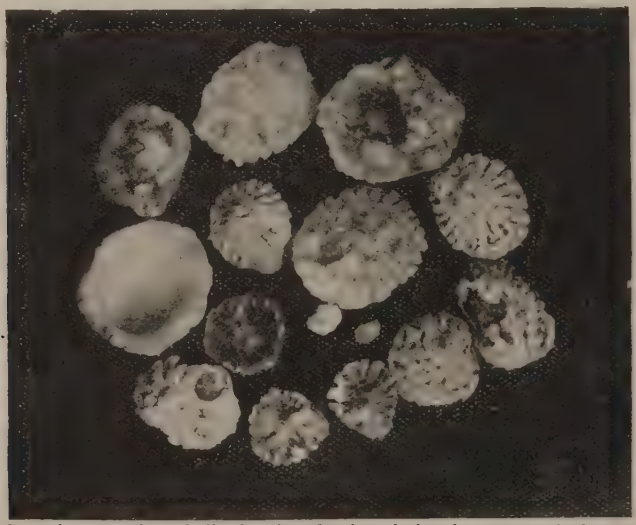

FIG. 1. *Saptadanta nasika :* shells showing the dorsal view in some and the ventral view in others. Depressions on some of the shells indicate reinfestation by younger individuals of the same species. x 1½.

Andamans. The occurrence of the same species on other shells of commercial importance recorded here for the first time, it is hoped, will be of some scientific interest. The availability of a large number of individuals enabled furnishing a detailed description of the conchological and other characteristics of the species.

The shell is fairly thick, low, conical, oval at base and whitish with a slightly greenish or brownish tint. The apex is a little recurved and placed at about a third of the distance from the posterior end. There is a varying number of radiating

ridges up to twenty-seven starting from the apical region and extending to the margin. The ridges are of a lighter hue than the intermediary grooves which are greenish or darkish brown. The peripheral region has a faintly marked groove a little away from the margin. When viewed from the ventral surface the edge of the shell presents well marked crenulations corresponding to the outer radiating ridges with the grooves in between. The inner surface of the shell is porcellanous and white. In a few comparatively thinner shells of smaller size and lighter build, the inner peripheral region has irregular brownish radiations alternating with light yellowish markings and the central deeper region a whitish brown colouration. The measurements of representative sample of shells of different sizes are given in table 1.

The observations being confined to dried up specimens, it was not possible to study the soft parts. The radula, however, was well preserved in the material examined and when it was moistened and cleared with a weak solution of caustic potash, it presented a structure which agreed in all details with the earlier description by Prashad and Rao (1934). The radular formula is 2.1.1.1.2. The central tooth is broad with a large median cusp and three other smaller ones on either side ; the lateral is arched with about eight cusps of which one is much larger than the rest ; the inner marginal is slender with a series of small cusps on its inner face and the outer marginal is stout, a little shorter than the one preceding it and bears short cusps on both the inner and outer faces at its tip.

Table showing measurements of shells with the number of radiations in Saptadanta nasika

Serial Number	Linear measurements in centimeters				Number of Ridges
	Length	Breadth	Apex to Ant. Margin	Height	
1*	1.35	1.20	1.10	0.41	26
2	1.35	1.29	1.27	0.53	24
3	1.30	1.00	1.00	0.45	25
4	1.30	1.00	1.00	0.40	25
5	1.40	1.00	1.20	0.48	27
6*	1.45	1.30	1.18	0.54	25
7*	1.05	0.90	0.80	0.30	19
8	1.08	0.98	0.85	0.35	25
9	1.20	0.70	0.90	0.30	25
10	1.05	0.88	0.85	0.36	27
11	1.05	1.00	0.78	0.21	21
12	0.75	0.78	0.65	0.30	21
13	0.80	0.75	0.65	0.20	18
14	0.90	0.88	0.82	0.32	27
15	0.85	0.80	0.70	0.21	22
16	0.65	0.50	0.45	0.20	22
17	0.60	0.50	0.48	0.25	24
18	0.50	0.35	0.25	0.15	20
19	0.45	0.30	0.30	0.15	24
20	0.30	0.25	0.20	0.10	20

* Reinfested with younger individuals of the same species.

The boundary of each one of the excavations on the surface of the shell has the same outline of the form which secures attachment and with a ring of close-set impressions conforming to the crenulations on the margin of the shell. The sides of the excavations are slightly sloping and the floor has a roughly oval ridge or elevation with a central depression. The ridge is a little higher and more conspicuous behind than in front and externally to it is a groove round the base. When two or more animals settle very close, the excavations made by them coalesce. Their formation is so characteristic that they can be identified and ascribed to the species even if the animals have dropped out of the infested shells.

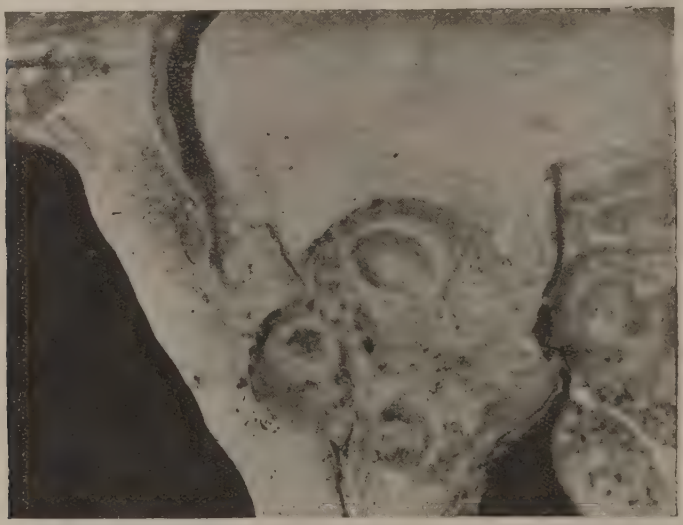

FIG. 2. *Saptadanta nasika :* excavations made by the form on *Pterocera* shell. Marginal row of close-set minute impressions and an oval ridge with a central depression may be noted. x 2.

In *Pterocera* the infestation has been found to be the highest close to the apical region although it occurs on other parts of the shell like the ventral surface of the body whorl and the fingered processes. Often the damage caused by the species is very great as nearly fifty and occasionally more have been found infesting a single shell. In the manufacture of fancy articles like flower vases and lamp shades *Pterocera* are largely used and those drilled with excavations caused by this species are considered unsuitable for the purpose.

I wish to express my very sincere thanks to Dr. S. Jones, Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp, for the keen interest taken in the preparation of this note.

Central Marine Fisheries Research Station,
Mandapam Camp.

K. VIRABHADRA RAO

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RECORD OF MALE *PARAPENAEOPSIS ACCLIVIROSTRIS* ALCOCK

WHILE revising the prawns of the Penaeus group Alcock (1905) created the species *acclivirostris* of genus *Parapenaeopsis*. The material he studied comprised 34 prawns, all females, obtained from Madras, Ganjam, Vizagapatam, the Palk Strait and the Persian Gulf. The male of this species has not been described so far.

A few small prawns, resembling young *Metapenaeus affinis* in general form and colour, were taken in the month of March 1960 from the 'dol' (fixed bag net) catches made off Sassoon Docks in Bombay at a depth of 6 to 7 fathoms. They measured 26 to 46 mm. from tip of rostrum to end of telson. Later in the same month, from an otter trawl catch from deeper waters of 15 to 20 fathoms off the same locality a large individual measuring 58 mm. was obtained. On close examination these prawns proved to be *Parapenaeopsis acclivirostris* Alcock. Out of the 19 individuals collected 9 are males.

Alcock's (1906) description and figures of the female tally with the present material in almost all details. The rostrum has 7 to 8 teeth and in the female it does not pass beyond the tip of the second segment of the antennular peduncle. The antennular flagella are subequal and 7/10 of the length of their peduncle in the female. The fifth pair of legs reaches almost to the tip of antennal scale.

The males are far smaller than the females. The 9 males examined are within a length range of 26 to 31 mm. and all of them appear to be adult as could be seen from the full development of their petasma. Three mature females with ripening ovaries measure from 44 to 58 mm. in length. The rostrum in the male just surpasses the eye and falls short of the tip of the basal segment of the antennular peduncle. The petasma reaches the basis of the third pereiopod. The distolateral projections of the lateral lobes are reflected posterolaterally making an angle of 60° with the longitudinal axis of the petasma. The distance between the tips of the projections is a little less than half the total length of the petasma. The width across the lateral lobes at their widest region is about a third of the petasmal length (Fig. 1 *a* and *b*). The distal piece of the appendix masculina is horse-hoof shaped, minutely setose and about half the length of the basal piece. On its posterodistal aspect are found one large and one or two smaller tongue like processes (Fig. 1 *c*).

Parapenaeopsis acclivirostris very closely resembles *P. tenellus* (Bate), and Alcock himself was doubtful of the validity of the new species he created. With the discovery of the male, its specific identity can now be established.

The main differences in the external sexual characters of the males of the two species are given below.

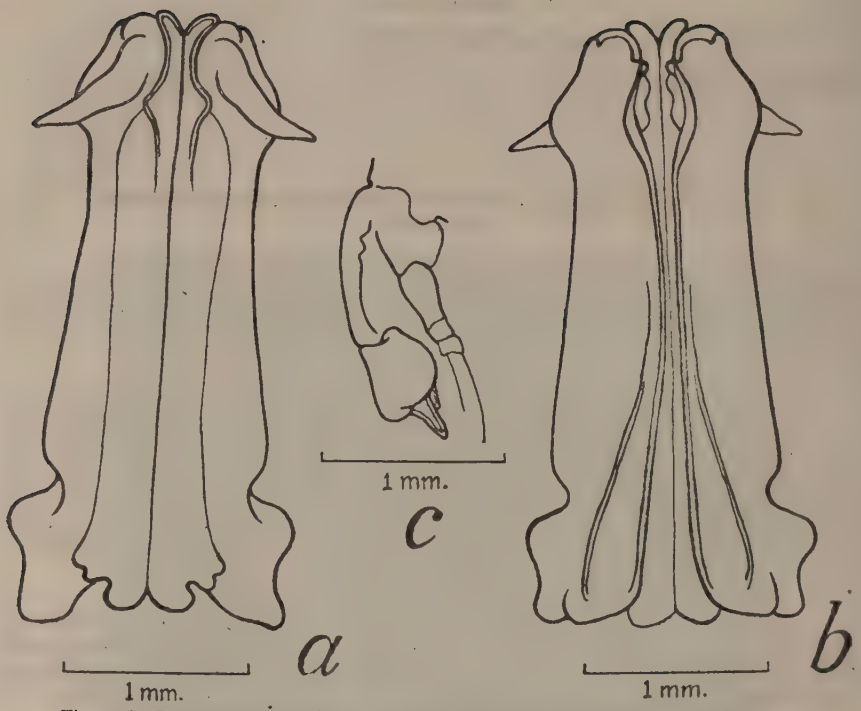

Figure 1. *Parapenceopsis acclivirostris* : Male, 30 mm. *a*. Dorsal surface of petasma ; *b*. Ventral surface of petasma ; *c*. Appendix masculina

Character	*P. acclivirostris*	*P. tenellus* (Kubo, 1949 ; Dall, 1957)
Petasma :	Disotolateral projections of the lateral lobes are not long and slender. Distance between tips of projections is a little less than half the petasmal length. Lateral lobes not expanded laterally ; distance across their most lateral extremities is about a third of the petasmal length.	Distolateral projections of the lateral lobes are long and slender. Distance between tips of projections is four-fifths of petasmal length. Lateral lobes are expanded laterally ; distance across their most lateral extremities is half the length of the petasma.
Appendix masculina :	Distal piece half the length of basal piece with two or three posterodistal tongue-like processes.	Distal piece a third as long as the basal piece with one posterodistal tongue-like process.

P. acclivirostris is one of the four species of *Parapenaeopsis* devoid of mastigobranchiae on the first and second pair of pereiopods. The other three are *P. hungerfordi* Alcock, *P. venusta* de Man, and *P. tenellus* (Bate). *P. acclivirostris* and *P.*

tenellus are remarkable species among Penaeinae in that they lack the isolated epigastric tooth.

I am thankful to Shri M. Krishna Menon, Research Officer (Prawns), Central Marine Fisheries Research Substation, Ernakulam for helpful criticism.

Central Marine Fisheries Research Substation, M. M. KUNJU
Bombay-1.

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ON THE SPECIFIC IDENTITY OF A RIBBONFISH (FAMILY TRICHIURIDAE) DESCRIBED BY HAMILTON (1822) FROM THE RIVER GANGES

IN the course of codifying the nomenclature of the species described by Hamilton in his ' Gangetic Fishes ' (1822), it was found that the description of one of the forms he had tentatively assigned to *Trichiurus lepturus* called for clarification as to its position in the System. It is evident that Hamilton, while recognising the similarities his specimens evinced to *T. lepturus*, was also aware of the many points of differences from its then known descriptions and drawings, for he remarked that ' . . . . I think it unnecessary to multiply distinctions, and shall only add a full description, so that those who have an opportunity may judge how far any differences to be observed in different places may be adequate to distinguish these kindred fishes into different species '. This description which appeared under his second Order Apodes which contained ' Fishes having the dorsal spine or bone and wanting ventral fins ' was not accompanied by a figure but the salient characters mentioned therein are as follows :

1. Elongate, with head and body considerably compressed, the latter resembling ' the blade of a very sharp sword '.

2. Colour, bright silvery throughout the body.

3. Head and body devoid of scales.

4. Lower jaw ending bluntly, but longer than the upper ; jaws with long distant teeth, and tips of each jaw with two teeth longer than the others.

5. Vent situated before mid-length of body ; tail having both edges sharp and mid-ventrally ' indented with almost seventy-four small prickles, and terminate in a very long slender point, which towards its end resembles a bristle '.

6. Eyes are placed high.
7. Gill-covers large and finely cut at edges ; gill-openings also large.
8. Lateral line decurved from nape and running along lower half of body.
9. Dorsal fin long with 114 rays.
10. Pectorals short, sharp above, each with 11 rays.

While several of the later ichthyologists have not remarked on Hamilton's description of this trichiurid, Day (1878) relegated it to the synonymy of *Trichiurus haumela* (Forskal) with no comments. Recently, Tucker (1956) had adduced reasons to show that *Trichiurus lepturus* Linnaeus and *T. haumela* (Forskal) are conspecific, the former name having priority over the latter, with which view we also agree.

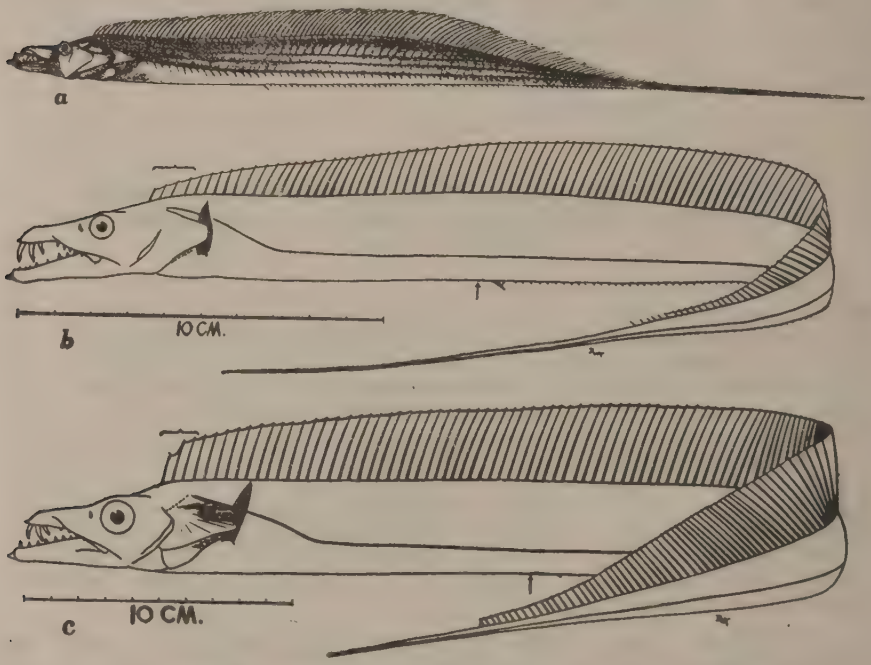

Figure 1. *a.* Hamilton's original figure of *Trichiurus lepturus* Lacépède (after Hora, 1929) ; *b. Lepturacanthus savala* (Cuvier) and *c. Trichiurus lepturus* Linnaeus (*b* and *c* after Tucker, 1956).

Hora (1929) found that original drawings of this trichiurid labelled as *Trichiurus lepturus* Lacépède, and those of some other species described by Hamilton, but not published by him during his time or subsequently by other workers did exist in the Asiatic Society Collections as well as at the British Museum (Natural History). The published figure of Hamilton's *T. lepturus* (Hora, *op. cit.*, pl. xviii, fig. 1) shows that it is in conformity with the description except that the dorsal fin is shown as

having 118 rays and the anal with 83 indented spinules instead of 114 and 74 respectively.

In the light of recent researches on the trichiuroids in general (Tucker, 1956), and certain species of these fishes occurring in Indian waters (James, 1959), it is now clear that Hamilton's description and drawing of *Trichiurus lepturus*, does not represent *Trichiurus lepturus* Linnaeus as redefined by Tucker (*cp. cit.*), but definitely depicts an allied species, *Lepturacanthus savala* (Cuvier) (=*Trichiurus savala* Cuvier, of Day and several other workers). The characters such as the dagger-like enlarged second anal spine (as shown in the drawing) ; the anal spinules breaking the ventral profile throughout the length of the fin and the spinules directed backwards ; the relatively smaller eyes (about 7.0 times in head length in the figure) ; the fin ray counts, and the bristle-like terminal part of the tail help in fixing the specific identity of this species as *L. savala*, at the same time distinguishing it from *T. lepturus* in which the corresponding anal spine is rudimentary ; the anal spinules absent or if present not breaking through the skin ; eyes large (5.0 to less than 7.0 in head length) and the terminal part of the tail relatively shorter and tapering gradually. However, as seen from Fisheries Reports, it is evident that *T. haumela* (=*T. lepturus*), also occurs in the Hooghly and Matla estuaries. In addition to these, two other lesser known ribbonfishes, namely *Eupleurogrammus intermedius* (Gray), and *E. muticus* (Gray) also occur in the Gangetic estuary as collections obtained by one of us from the Matla and Hooghly estuaries indicate. Both *L. savala* and *T. lepturus* are easily distinguishable from the genus *Eupleurogrammus* Gill in several characters including the decurved lateral line and the total absence of the pelvic fins. The diagnostic characters of these four Indian species and a synopsis to their identification have been given elsewhere (James, 1959).

Incidentally it may be mentioned here that all these four species have also been obtained from fish catches landed at Sassoon Docks, Bombay, on a single day. It has been interesting to find that at many places where they are fished or form part of regular catches along the Indian coast, more than one or all these four species of trichiurids occur even in a single haul which has often presented difficulties to the untrained eye in distinguishing them.

Summary

Trichiurus lepturus Hamilton (*nec* Linnaeus) is relegated here to the synonymy of *Lepturacanthus savalva* (Cuvier). Attention is also drawn to the occurrence of the four Indian species *Trichiurus lepturus* (of which *T. haumela* (Forskal) is a synonym), *Lepturacanthus savala*, *Eupleurogrammus intermedius*, and *E. muticus* in the Gangetic estuary and along the Bombay Coast.

Central Marine Fisheries Research Station,
Marine Fisheries P.O.
Mandapam Camp.

E. G. Silas
P. S. B. R. James

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A SHORT ACCOUNT OF THE WAHOO, *ACANTHOCYBIUM SOLANDRI* (CUVIER & VALENCIENNES)

RECENTLY it has been possible to collect a few specimens of *Acanthocybium solandri* from Vizhingam (Lat. 08° 22′ N., Long. 76° 59′ E.), South-West Coast of India ; and a description of the species is given below, as no account of it is available from Indian waters, except for a mention of its occurrence around Minicoy Island by Jones and Kumaran (1959) and in the Wadge Bank area off Cape Comorin by John (1959).

A. solandri is widely distributed, and is recorded from the circum-tropical parts of the Pacific, Atlantic and Indian Oceans. The first record of this species from the Indian Ocean (Arabian Sea) is that of Boulenger (1897) who gives a detailed description of a specimen collected and sent to the British Museum by Surgeon-Lieut.—Col. Jayakar from Muscat. Other records of this fish from the Indian Ocean are from the Delagoa Bay and Durban coasts in South Africa (Smith, 1949) ; Ceylon coast (Deraniyagala, 1952 ; Munro, 1955) ; and from Minicoy Island (Jones and Kumaran, 1959) ; the Wadge Bank area in India* (John, 1959) ; and subsequently from Andamans and Tuticorin (Jones, Silas and Dawson, 1960).

DESCRIPTION

Acanthocybium solandri (C. & V.)

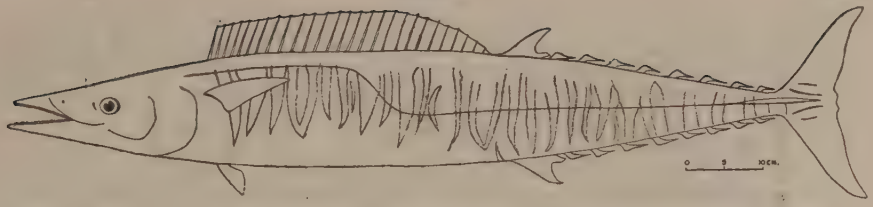
Cybium solandri Cuvier & Valenciennes 1841, *Hist. Nat. Poissons*, 8, 192.

Acanthocybium solandri. Boulenger, 1879, *Proc. Zool. Soc. London*, 272 ; Hardenberg, 1934, *Treubia*, 14(3) 292 ; Smith, 1949, *Sea fishes of South Africa*, 301, PL. LXIV, fig. 843 ; Fraser-Brunner, 1950, *Ann. Mag. Nat. Hist.*, (12) 3 : 162, fig. 35 ; de Beaufort, 1951, *Fishes of the Indo-Australian Archipelago*, 9: 228 ; Deraniyagala, 1952, *Coloured Atl. Some. Vert. Ceylon, I, Fishes*, 100-101, figs. 47, 48 ; Munro, 1955, *Marine and Fresh water Fishes of Ceylon*, 220, pl. XLIII, fig. 649 ; Jones and Kumaran, 1959, *Indian J. Fish.* 6(1) : 49 ; John, 1959, *Bull. Centr. Res. Inst., Univ. Kerala*, 7(1) : 133; Jones, Silas & Dawson, 1960. *J. Mar. biol. Assoc. India*, 2 (1). 134

Dl. XXIII-XXVII ; D2. III, 9—10+8—10 ; A. III, 9—10+7—9 ; P. ii.21 ; V. I, 5 ; Vert. 62-64.

Body, enlongated and cigar-shaped, covered with small, narrow, rhomboidal scales ; those at the base of vertical fins elongated and lanceolate. Head, very long

* Dr. S. Jones, Chief Research Officer, in a personal communication informs me that he has seen a specimen of *A. solandri* on 16-3-1956 at Colachel (South of Vizhingam).



Acanthocybium solandri (Cuvier & Valenciennes)

and slender. Depth of body 6.2-6.8, length of head 4.0-4.3, caudal 8.4-9.5 in standard length. Diameter of eye 9.2-9.8 in length of head, and 2.5 in interorbital space. Snout long and beak-like, 1.9-2.1 in length of head. Cleft of mouth wide, extending to below anterior edge of eye; posterior part of maxillary covered by the preorbital. Jaws strong, set with a series of trenchant, closely set, slightly serrated teeth which increase in size posteriorly ; about 40-45 such teeth in lower jaw and 45-50 in upper jaw. Chin pointed, slightly projecting. Villiform teeth in a club-shaped patch on vomer and in an elongated band on palatines. Branchial lamellae reticulate. Gill-rakers absent. Preopercular edge slightly serrated. Anterior dorsal, well developed, high, a little longer than second dorsal, originating above base of pectoral ; spines sub-equal, highest behind middle of fin, $\frac{1}{4}$ length of head. Second dorsal, small, originating a little in advance of anal which is similar to former. Pectoral, originating a little anterior to origin of anterior dorsal, 1.9-2.2 in head, reaching to below 10-11th dorsal spine. Ventrals small, thoracic, about half length of pectoral. Caudal, short, lunate and 1.9-2.2 in head. Lateral line, with many perpendicular branches, high at anterior part of body, descending abruptly in a strong curve below the second third of anterior dorsal, terminating on tail in a strong keel which is about $\frac{1}{2}$ length of head. Number of vertebrae 62-64.

In fresh condition colour of the body is steel-blue above and paler ventrally. Sides with 25-30 vertical faint bars. Anterior dorsal similar to body in colour, but paler. Second dorsal, pectoral and caudal fins blackish ; ventrals and anal dusky.

General Remarks

The various body measurements and fin counts of *A. solandri*, taken from fresh material, are given in the Tables 1 and 2. The above description is based on these measurements. The figure is drawn, proportionately, based on the measurements taken from fish No. 4.

No significant differences are noticed in the various body proportions and the fin counts of *A. solandri* described from the Indian waters and from other places, except from Indonesia (Hardenberg, 1934). In his description of the species from Indonesian waters, Hardenberg (*l.c.*) gives the second dorsal fin count as 7. This is probably an error which is later followed by de Beaufort (*l.c.*), and Munro (*l.c.*). It may also be mentioned here that the specimen described by him has comparatively shorter head, which is contrary to all existing description of the species both from the Indo-Pacific and the Atlantic. The number of fin rays in the second dorsal is also 11-13 (its range in the present material is 12-13) and not 7.

A. solandri, known as *Oria Neemeen* or simply *Oria meen* in the local dialect, appears to be not very common at Vizhingam. This fish is occasionally caught

TABLE I

Body Measurements of *Acanthocybium solandri* in mm.

S. No.	Date	Weight Kg.	Sex & Stage of maturity	Furcal length	Standard length *	Greatest body depth	Head length	Maxillary length	Snout length	Eye diameter	Snout to pectoral	Snout to ventral	Snout to 1st dorsal	Snout to 2nd. dorsal	Snout to anal	Pectoral length	Pelvic length	Height of 1st. dorsal **	Height of 2nd. dorsal	Height of anal	Vertebrae
1	20-11-1959	10.51	♀ II	1,200	1,122	170	260	132	130	28	275	295	280	690	745	135	70	55	52	61	—
2	24-11-1959	10.06	♂ II	1,130	1,045	160	242	121	124	25	252	257	262	657	694	128	66	57	55	55	64
3	17-12-1959	8.23	♀ II	1,055	984	168	245	120	125	25	258	267	274	634	667	128	58	54	52	51	63
4	5- 1-1960	7.31	♂ II	1,054	985	148	231	115	112	25	246	263	253	631	650	112	52	46	43	56	—
5	22- 1-1960	11.43	♀ II	1,205	1,128	182	265	135	137	28	281	305	286	701	756	128	60	55	59	65	62
6	8- 2-1960	8.23	♂ II	1,139	1,064	157	259	131	131	27	272	283	276	680	722	120	66	57	56	54	—
7	17- 3-1960	7.77	♀ II	1,090	1,020	153	247	124	121	26	256	265	272	—	—	—	—	—	—	—	62

* From the tip of snout to the origin of caudal fin.
** Height of 1st dorsal taken at 1st. dorsal spine.

in November-March by open-sea fishermen using No. 1 hooks, baited with sprats, goat--fishes and squids. During the above period this species is reported to have been caught also at other centres south of Vizhingam ; and often brought to the Connemera Market, Trivandrum.

TABLE II

Fin Counts of *A. solandri*

Serial No. of fish	1st dorsal fin	2nd dorsal fin	Dorsal finlets	Anal fin	Anal finlets	Pectoral fin	Ventral fin
1	XXVI	III, 9	10	III, 9	8	ii, 21	I, 5
2	XXVI	III, 10	8	III, 10	8	ii, 21	I, 5
3	XXV	III, 10	9	III, 10	9	ii, 21	I, 5
4	XXVII	III, 10	8	III, 10	8	ii, 21	I, 5
5	XXV	III, 9	9	III, 10	8	ii, 21	I, 5
6	XXV	III, 10	8	III, 10	7	ii, 21	I, 5
7	XXIII	III, 10	9	III, 10	8	ii, 21	I, 5

The Wahoo is a large oceanic and pelagic fish ; voracious in habits, feeding mainly on other pelagic and shoaling fishes. Examination of the stomach contents of the specimens collected at Vizhingam showed that they were mainly feeding on shoaling fishes like frigate mackerel (*Auxis thazard*), Indian mackerel (*Rastrelliger kanagurta*) and other scombroid fishes. All the specimens examined from Vizhingam are immature.

Two types of parasities have been collected from *A. solandri* examined from Vizhingam. One of them is a large species of digenetic trematode found in the stomachs of all the fish examined ; and it appears to be similar to the species of *Distomum*, recorded by Kishinouye (1923) from the stomachs of this fish from Japan. Another is an interesting lernaeid copepod parasite, which has not yet been identified, collected from the body wall of the fish No. 5 in the present material. These external copepod parasites are tough in texture, very much elongated and thread-like (10.5-12.0 cm. in length), and with an anterior lobed organ which gets embedded in the body wall of the fish to get firm hold, while the rest of the parasite is suspended freely outside. Their general colour when fresh is bluish-green.

I am greatly indebted to Dr. S. Jones, Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp for the encouragement and help in the preparation of this note. My sincere thanks are also due to the Superintendent, Trivandrum Zoo, for kindly extending library facilities to me.

Central Marine Fisheries Research Centre,
Vizhingam P.O., Kerala

K. V. NARAYANA RAO

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NEW RECORDS OF SCOMBROID FISHES FROM THE ANDAMAN-NICOBAR WATERS

In the course of a visit to the Andamans and Nicobars during February-March 1960, we were able to obtain seven species of Scombroid fishes, six of which have not hitherto been recorded from this area, and two of which are new records for the Indian Seas. In fact, Herre (1941), while listing 490 species of fishes from the Andaman waters drew attention to the paucity of our knowledge of the pelagic fishes of the area. He recorded only three scombroid species, namely, *Scomber microlepidotus* Ruppell, *Rastrelliger brachysoma* (Bleeker), and *Rastrelliger kanagurta* (Ruppell). Of these, *S. microlepidotus* is now considered to be a synonymy of *R.canagurta*, thus leaving only two scombroid species as having been recorded from this area. Our collections include the following species :

1. The Indian Mackerel, *Rastrelliger canagurta* (Cuvier) : 3 specimens between 225 and 250 mm. from Port Blair, Andamans.

2. The Eastern Little Tunny, *Euthynnus affinis affinis* (Cantor) : 1 specimen 562 mm. caught off Port Blair, Andamans. New record for Andamans and Nicobar waters.

3. The Double-lined Mackerel, *Grammatorcynus bicarinatus* (Quoy & Gaimard) : 1 specimen, 449 mm. taken on hook and line off Ross Island, Port Blair, Andamans. New record for Indian Seas.

4. The Dog-toothed Tuna, *Gymnosarda unicolor* (Ruppell) : 3 specimens measuring 514, 680, and 685 mm. caught off Port Blair, Andamans. New record for Indian Seas.

5. The Striped Seer, *Scomberomorus* (*Cybium*) *commerson* (Lacépède) : 2 specimens taken on troll line between Long Island and Mayabundur and one specimen caught off Ross Island, Port Blair, Andamans. New record for Andamans and Nicobar waters.

6. The Wahoo, *Acanthocybium solandri* (Cuvier & Valenciennes)* : 2 specimens 1020 and 1200 mm. taken on troll line between Long Island and Mayabundur, Andamans. New record for Andamans and Nicobar waters. Hitherto reported from Indian waters from only the Laccadive Seas (Jones & Kumaran, 1959) ; and the Wadge Bank off Cape Comorin (John, 1959). In July, this year, we obtained one specimen from Tuticorin. Deraniyagala (1952) has recorded this species off Ceylon coast.

7. The Sail Fish, *Iistiophorus gladius* (Broussonnett) : Skeleton and fin of one specimen caught off Malacca Bay, Car Nicobar in 1958. New record for Andamans and Nicobar waters.

The Atlas *cum* Report on the "Average year's fishing conditions of the Tuna long-line fisheries" edited by the Nankai Regional Fisheries Research Laboratory

*For information regarding the occurrence of this species in the Indian Ocean, reference is invited to the note by Narayana Rao (1960). *J. Mar. biol. Ass. India*, 2(1) ; 130-33

(1958 edition, published in July 1959) indicates that the Japanese long-line fishing operations in the Andamans and Nicobar waters at different months of the year yielded seven commercially important species hitherto not reported from that area. They are, *Thunnus germo* (Lacépède), *Thunnus orientalis* (Temminck & Schlegal), *Parathunnus mebachi* (Kishinouye), *Neothunnus macropterus* (Temminck & Schlegal), *Xiphias gladius* (Linnaeus), *Kajikia mitsukurii* (Jordan & Snyder), and *Eumakaria nigra* (Nakamura). More recently, Nakagome (1959 *a* & *b*) has also indicated the occurrence of the Yellowfin Tuna, *Neothunnus macropterus*, and the Big-eyed Tuna, *Parathunnus mabachi* from the Andamans and Nicobar waters.

Besides these species, it will not be surprising if improved fishing methods and more intensive surveys eventually show that other Scombroids, such as the Skipjack, *Katsuwonus pelamis* (Linnaeus) ; the Oriental Bonito, *Sarda orientalis* (Temminck & Schlegal) ; the Frigate Mackerels, *Auxis thazard* (Lacépède) and *A. thynnoides* Bleeker ; the Indian Spanish Mackerel, *Scomberomorus* (*S.*) *guttatus* (Bloch & Schneider) ; the Indian Long-tailed Tunny, *Kishinoella tonggol* (Bleeker) ; the Short-nosed Spear Fish *Tetrapturus brevirostris* (Playfair) ; etc., which occur in the tropical Indian Ocean and in the Indian Coastal waters are also present in the Andamans and Nicobar waters.

Central Marine Fisheries Research Station,
Marine Fisheries P.O.

S. Jones
E. G. Silas
E. Dawson

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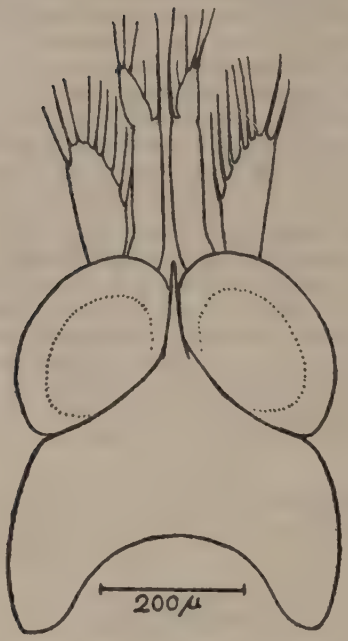
NOTES ON SOME DECAPOD LARVAE—A CORRECTION

In our description of the first larval stage of *Anchistus inermis* (*J. zool. Soc. India*, 9, 22-39, 1957) we had stated that the larva has no rostral spine. However, since Dr. Bruce pointed out in a recent personal communication the presence of a distinct rostral spine in *A. incomis* Miers, *A. miersi* (de Man) and *Paranchistus* (?) *biunguiculatus* Borradaile, although short in *Paranchistus*, we re-examined our material. We have now discovered that the first larva of *A. inermis* also possesses a short rostral spine. In the freshly hatched larva the spine is usually curved and hidden by the large eyes and is likely to escape notice. The revised illustration given here shows the rostrum in *A. inermis* in a dorsal view.



Our thanks are due to Dr. A. J. Bruce, East African Marine Fisheries Research Organisation, Zanzibar, for drawing our attention to this fact.

Central Marine Fisheries Research Station,
Mandapam Camp.

R. RAGHU PRASAD
P. R. SADASIVAN TAMPI

NEWS AND COMMENTS

Extension to Plymouth Laboratory

The announcement of an extension building to the Marine Laboratory at Plymouth comes as a welcome news to marine biologists all over the world. The £100,000 building is hoped to be completed by the end of the summer of 1961 and will house a laboratory each for physiology, chemistry and botany, besides a lecture hall. The project is intended to increase the accommodation and facilities for both the existing staff and visiting scientists.

Co-operative Survey of the Iceland Sea

The recent expedition sponsored by the International Council for the Exploration of the Sea and under the leadership of Dr. John B. Tait of the Marine Laboratory, Aberdeen, has completed its three weeks' survey of the region between Faroe Island and Iceland. During this biggest-ever marine probe (up to a depth of 2,500 meters below the surface) in which survey ships of Britain, Russia, Germany, Norway and Iceland co-operated, data of considerable value on the fertilization of the sea were gathered. The expedition was particularly concerned with the question of ' overspill ' of cold ' heavy ' water believed to affect the flow of nutrient salts at great depths which influence the marine vegetation on which fish depend for their food.

National Oceanographic Research Committee for India

The Government of India have constituted a seven-man National Committee for Oceanographic Research under the Chairmanship of Dr. D. N. Wadia, for organizing research relating to the Indian Seas.

The Bergen National Fisheries Fair

A fascinating and varied review of the Norwegian fishing industry is being presented in Bergen during the National Fisheries Fair from August 25th to September 11th 1960, under the auspices of the Ministry of Fisheries. One of the major attractions of the fair will be the hydrosome, 90ft. British stern trawler *UNIVERSAL STAR* equipped with the new McGregor trawling device.

New Fishery Research Vessels

TELLINA.—The launching of the 55 ft. fishery research vessel *TELLINA* in June 1960 from the Jones shipyard at Buckie, U.K., should be of special interest to marine biologists who would be looking forward to the wealth of information that would be collected after this vessel starts operation along with the fleet of four others at Lowestoft, U.K.

THYRSITES.—In order to work out mainly the cause of the decline of barracouta fisheries in the Bass Strait (between Victoria and Tasmania) CSIRO will use a new fisheries research vessel *THYRSITES.* The vessel is 42 ft. long, with a cruising range of 1,900 miles at 8 knots and has a well equipped laboratory for two scientists. During her important investigations on the barracouta research programme, continual water sampling and plankton collections will also be carried out.

CAPE ST. MARY.—The research vessel *ALISTER HARDY* of the Fisheries Research. Unit of the University of Hong Kong was replaced early in 1960 by the research trawler *CAPE ST. MARY* (238 gross tons and 130 feet). This trawler is equipped with laboratories for biological and chemical studies and berths for three scientists. In addition, she has echo-sounder, radar, and radio transmitter and receiver. The vessel's programme includes a trawling, and hydrological and plankton survey of the continental shelf between the gulf of Tongking and the south coast of Taiwan.

Big Fish on Seven-Mile Long-Line

The experimental long-line fishing in the Indian Ocean off the East African coast conducted by the *MANIHINE* ' floating laboratory ' of the East African Marine Fisheries Research Organization seems to open up possibilities of a new industry. *MANIHINE'S* 1,000 mile cruises over the Indian Ocean to discover fishing grounds for the larger varieties of fish have proved profitable and she has already captured some of the prized varieties such as marlin and others in the seven-mile long-line she lays each day of her cruise.

Cahiers De Biologie Marine

The publication of another Journal in Marine biology from October 1960, entitled *Cahiers de Biologie Marine*, from the Station Biologique de Roscoff, Paris, which will contain several articles on the marine fauna of the French coast, will be a welcome news to marine biologists.

The Sea Cow Conservation

The steps taken by the Marine Biological Association of India to conserve the sea-cow (*Dugong dugong*) in the Pamban area (as already reported in the *Journal of the Marine Biological Association of India* Vol. I (2) 1959) are noteworthy. It is hoped that eventually similar conservation measures would be extended in the case of other marine fauna and flora of these regions which show signs of depletion.

VITIAZ Expedition

The Russian research vessel *VITIAZ* left Cochin on 4th February 1960 and covered the western half of the Indian Ocean, touching Maldives, Madagascar, Comoro, Zanzibar and Seychelles. In all, observations were made at 97 stations along her route. The vessel called at Bombay on 4th April 1960 and she sailed to Odessa on the 9th April. *VITIAZ* is expected to come back sometime in October 1960 to work in the Arabian Sea and the Bay of Bengal.

OPERATION MONSOON

Sponsored by the Scripps Institution of Oceanography, the *Operation Monsoon* is expected to conduct detailed oceanographic cruise between August 1960 and February 1961. She is expected to cover more than 35,000 miles, operating mostly between 0 and 20 degrees south.

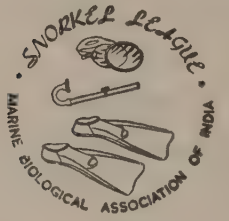
Atlantic Ocean Atlas

To chart the possibility of farming and mining the oceans for new sources of food, fuel and minerals, the American Geographical Society has begun work on a comprehensive atlas of the North Atlantic Ocean. It is expected to provide scientists with a new research tool for making comparative studies of the interrelationships of marine organisms and their environments.

U.N. Conference on the Law of the Sea

The United Nations Conference on the Law of the Sea in Geneva concluded on April 1960, without any conclusive resolutions on vital problems affecting the width of the territorial sea and fishing zones. It did, however, adopt a proposal expressing the need for technical assistance in fisheries.

THE SNORKEL LEAGUE



The Snorkel League had a season of hectic activity with the placid waters of Palk Bay offering the ideal conditions for skin diving. The 'Olavalai ' operations followed by skin diving conducted on most of the holidays continued to attract great number of enthusiasts. These trips have provided opportunities for the members to make on the spot study of the marine fauna. Particularly, many interesting observations were made on animal associations in the natural surroundings.

The highlight of the activities was an aquatic sports meet held on 28th May 1960 in Palk Bay, the first of its kind in India, in which many leaguers took part. The meet was witnessed by a large and distinguished gathering including Shri. K. R. Damle, Secretary to the Ministry of Food and Agriculture, Government of India and Mrs. Damle. At the end of the meet Mrs. Damle distributed the prizes to the winners. The League's felicitations to Shri. C. Sankarankutty, the champion of the meet.

The Leaguers had an opportunity, while on an official tour to the Andaman and Nicobar Islands early in February, to make observations of the coral beds in the deep blue lagoons around the islands, which are known to be the paradise for underwater study.

The activities of the League continued to attract many distinguished visitors to the Headquarters. Professor S. Kavaguti, eminent Scientist from Japan and Shri. Tissevirashinghe of the Ceylon Salt Commission accompanied by some members of the League and the Honorary Adviser, Shri. Rodney Jonklass, visited the coral reefs of Gulf of Mannar. The League also had the privilege of initiating Shri E. C. P. Prabhakar, I.A.S., Collector of Ramanathapuram, to its diving activities. It is noteworthy that the Films Division of the Government of India, Ministry of Information and Broadcasting has filmed some of the activities of the League in its coverage of the Marine Biological Research at Mandapam.

It is hoped that the endless vistas of the underwater world would be further opened up to the members of the Snorkel League with the arrival of Aqualung and other underwater appliances.

CONVENER

AMENDMENTS TO THE CONSTITUTION

The following amendments to the Constitution were passed at the First General Body Meeting held on December 20, 1959

that Article 4(d) of the Constitution :—

' **Honorary Members :** Honorary Members shall be persons of eminence by their contribution to Marine Biological and allied Marine Sciences. There shall not be at any time more than fifteen Honorary Members and not more than one shall be elected each year except the first year when not more than seven shall be elected '

amended to read as :—

' **Honorary Members :** Honorary Members shall be persons of eminence by their contribution to Marine Biological and allied Marine Sciences. There shall not be at any time more than five Honorary Members and not more than one shall be elected each year except during the first year.'

that Article 5 of the Constitution :—

' The annual subscription for ordinary members residing in India shall be Rs. 10 (Rupees Ten) and in the case of Members residing outside India it shall be $2.50 (Two and a Half U.S. Dollars) or *sh.* 17-6*d* (Seventeen and a Half Shillings); payable in one instalment. Institutional membership subscription shall be Rs. 15 (Rupees fifteen) in India and $4.00 or *sh.* 30 outside India. The entrance fee for ordinary members joining the Association in the first year of its inception shall be Rs. 2 (Rupees Two) for those residing in India and $0.50 (Half a U.S. Dollar) or *sh.* 3-6*d* (Three and a Half Shillings) for those residing outside India. The entrance fee for membership in the subsequent years to the year of inception of the Association shall be Rs. 5 (Rupees Five) for those residing in India and $1.00 (One U.S. Dollar) or *sh.* 7-6*d* (Seven and a Half Shillings) for those residing outside India.'

amended to read as :—

' The annual subscription for Ordinary Members residing in India shall be Rs. 10 (Rupees Ten) and in the case of members residing outside India it shall be Rs. 12-50 (Rupees Twelve and a Half) payable in one instalment. Institutional membership subscription shall be Rs. 15 (Rupees Fifteen) in India and Rs. 20 (Rupees Twenty) outside India. The entrance fee for ordinary members joining the Association after the first year of its inception shall be Rs. 5 (Rupees Five).'

that Article 6(a) of the Constitution :—

' Ordinary Members may become **Life-Members** on payment of Rs. 150 (Rupees One Hundred and Fifty) in one or more instalments within a year from the date of their application for Life-Membership.'

amended to read as :—

' Ordinary Members residing in India may become Life-Members on payment of Rs. 150 (Rupees One Hundred and Fifty) in one or more instalments within a

year from the date of their application for Life-membership. Likewise, members residing outside India may become Life-members on payment of Rs. 200 (Rupees Two Hundred).'

that Article 15 of the Constitution :—

' **Executive Council :** The Association shall be administered by a President, a Vice-President, two Secretaries, a Treasurer, an Editor of the Journal and six members. Either the President or the Vice-President and the Treasurer and one of the Secretaries shall be residents at the Headquarters of the Association. The Resident Secretary with the approval of the Executive Council shall appoint an Assistant Secretary to help him. The Assistant Resident Secretary shall hold office for three years. In the absence of the Secretary in any meeting of the Executive Council the Assistant Secretary will be co-opted and his presence shall count towards the required quorum.'

amended to read as :—

' **Executive Council :** The Association shall be administered by a President, a Vice-President, two Secretaries, a Treasurer, an Editor of the Journal and six members. Either the President or the Vice-President, the Treasurer and one of the Secretaries shall be residents at the Headquarters of the Association. The Resident Secretary with the approval of the Executive Council shall appoint an Assistant Secretary to help him. In the absence of the Secretary in any meeting of the Executive Council the Assistant Secretary will be co-opted and his presence shall count toward the required quorum. The Treasurer with the approval of the Executive Council shall appoint an Assistant Treasurer to help him. In the absence of the Treasurer in any meeting of the Executive Council, the Assistant Treasurer will be co-opted and his presence shall count toward the required quorum. The Assistant Secretary and the Assistant Treasurer shall be residents at the Headquarters of the Association.'

that Article 16 of the Constitution :—

' The term of office of all Members of the Executive Council shall be three years and the Members of the said Council shall be elected by the Members present at the first General Body Meeting and thereafter by the Members present at every third annual General Body Meeting.'

amended to read as :—

' The term of office of all Members of the Executive Council shall be three years and the Members of the said Council shall be elected by the Members present at the first General Body Meeting and thereafter by the Members present at every third annual General Body Meeting. The Office-bearers elected by the Executive Council shall hold office for a period of one year and they shall be eligible for re-election.'

that Article 18 of the Constitution :—

' The Editor with the approval of the Executive Council shall constitute an Editorial Committee of himself, and two other Members, viz., a Joint Editor and a Managing Editor. The Managing Editor shall be a resident at the Headquarters of the Association. In the absence of the Editor in any meeting of the Executive

Council, the Managing Editor will be co-opted and his presence shall count towards the required quorum. The Editorial Committee, like the Executive Council, shall hold office for three years '

amended to read as :—

' The Editor with the approval of the Executive Council shall constitute an Editorial Committee of himself, and two other members, viz., a Joint Editor and a Managing Editor. The Managing Editor shall be a resident at the Headquarters of the Association. In the absence of the Editor in any meeting of the Executive Council, the Joint Editor will be coopted and his presence shall count toward the required quorum. In the absence of both the Editor and the Joint Editor in any meeting of the Executive Council, the Managing Editor will be co-opted and his presence shall count toward the required quorum. The Editorial Committee, like the Executive Council, shall hold office for three years.'

that Article 20 of the Constitution :—

' Applications for the formation of Local Branches shall be considered by the Executive Council provided there are at least five members desirous of forming a branch '

amended to read as :—

A. Application for the formation of a local branch shall be considered by the Executive Council provided there are at least five members desirous of forming a branch.

B. Not more than one branch shall be permitted in each town and no branch shall be permitted to act in a way which shall go against the declared objects or the dignity of the Association.

C. Each local branch shall elect a Chairman, Secretary and such other Office Bearers as decided by the members of the branch.

D. The local branch may raise funds either by donation or by any local activity. Such funds shall belong to that branch and shall be managed by the Office Bearers of that branch.

E. The local branch may enroll *bona-fide* students as student members of the branch. The only privilege of the student members shall be to participate in the meetings and functions of the Association. The annual subscription for the student members shall be fixed by the local branch.

F. The branch Secretary shall send the Resident Secretary periodical reports of the activity of the branch giving the names of the members and Office Bearers, the number and dates of meetings held, the papers read at meeting etc. An annual statement of accounts duly audited by the local branch shall be sent to the Treasurer of the Association after the end of the financial year.

Article 24.

The Annual General Body meeting will be held ordinarily between December 15 and January 15.

that Regulation III of the Constitution :—

'The Executive Council shall incur all items of expenditure including the publication of the Journal from the General Funds of the Association. On any special items of expenditure exceeding Rs. 500 the approval of the General Body shall be obtained before such expenditure is incurred. During the course of a year the Treasurer shall not incur expenditure exceeding a sum of Rs. 200 on items for which it is not possible to obtain the prior approval of the Executive Council.

amended to read as :—

'The Executive Council shall incur all items of expenditure including the publication of the Journal from the General Funds of the Association. On any special items of expenditure exceeding Rs. 500 (Rupees Five Hundred) excluding the publication of the Journal, Memoirs and Monographs, the approval of the General Body shall be obtained before such expenditure is incurred. During the course of a year the Treasurer shall not incur expenditure exceeding a sum of Rs. 200 (Rupees Two Hundred) excluding purchase of stationery articles and cost of postage, on items for which it is not possible to obtain the prior approval of the Executive Council.'

BOOK REVIEW

MARINE BIOLOGY in *Transactions of the Institute of Oceanology*, Vol. XX, 302 pp., 1957 (Price 10.00 Dollars in the U.S.), is one of six Russian monographs in biology that are concurrently being translated into English and is published by the American Institute of Biological Sciences, Washington D.C. The sumptuous volume under review contains thirteen contributions by Russian authors dealing mainly with the marine plankton, the bottom fauna and the age, growth, and development of fishes. There is an article each on Bivalve molluscs and the Hyperiid Amphipoda. The geographical area covered in these contributions extends over the Northern Seas of the U.S.S.R., the Black Sea, the Sea of Azov, the Far Eastern Seas, and the Northwest Pacific Ocean.

Within the limited space available for the present review, it would not be possible to refer to more than three or four of the contributions which find a place in this volume.

The study of the bivalve fauna of the Northern Seas has shown its close relationship to the fauna of the N. Atlantic and the impoverishment of certain systematic categories indicated by the fact that certain families are represented here by one genus and species and due to the fact that stenobiontic species of boreal origin cannot live in the arctic conditions. In spite of the small number of species, the bivalve molluscs are characterised by large numbers and biomass, and dominate the bottom fauna communities indicating that as a whole they are a progressive and flourishing group well on the way to the adaptive formation of new forms.

Various aspects of the groupings of the benthic fauna in relation to available food and modes of feeding seem to have received considerable attention at the hands of several workers. The tables of biomass of different biological groups of bottom animals at various stations, and of the dominant groups of species in individual biocoenosis given in two of the articles provide much information of value to fishery biologists.

In an interesting article on the spatial interrelationships of marine zoo-and phytoplankton, the possible reasons for the occurrence of certain cases of direct and inverse relationships between the numbers of copepods and diatoms are discussed and the causes of the mutual location of zoo-and phytoplankton, according to various theories, are examined.

The contribution on the feeding of some carnivorous deep-sea benthic invertebrates (Decapod crustacea, asteroids and ophiuroids) is of special interest in view of the great importance attaching to the trophic factor (in benthic Inverterbates living at great depths in the oceans in conditions of extreme impoverishment of the food supply) and its bearing on many features of the distribution of the bottom fauna.

The study of the age and growth of the cod (Gadidae), *Elaginus* of the Kara Sea has brought out certain interesting results, e.g., that they attain a size of 45 cm. in twelve years, and almost one-fifth of this size by the end of the first year, and growth

slows down with the onset of sexual maturity after three years, as seen in the annual and winter ring of the otolith. In age determination of Kara Sea Cod, *Elaginus*, by means of otoliths, accuracy and ease of operation are claimed for the method of study in which the otolith is broken in two by hand or forceps, and each half is flamed for a few seconds over a spirit lamp before examination under a binocular, which reveals the fracture planes in the form of distant dark brown rings, assumed to be annual rings (Fig. 1 on p. 249).

The volume is well printed on good paper and its general get-up, is so good that its high price may not prove to be a disincentive for any Biological Library to have it on its shelves.

H.S.R.

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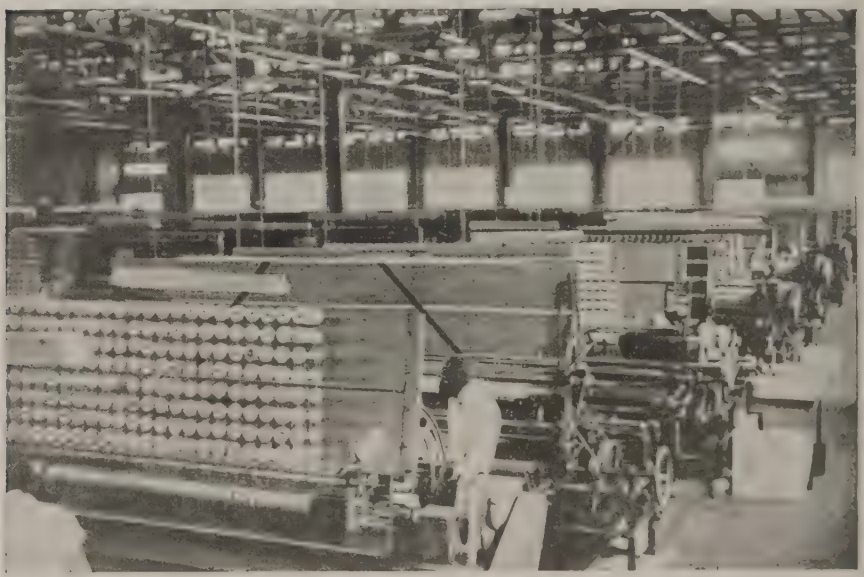

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3. Tables when given should not contain bulky data and should be given on separate sheets and their position in the text indicated suitably. They should be neatly typed without any overlapping of the columns and should be given brief headings. They should be numbered in Roman numerals and indicated in the text thus : Table I.

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